THE CALLENDAR STEAM TABLES

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WITH STEAM DIAGRAM IN POCKET

LONDON
EDWARD ARNOLD
1915

INTRODUCTION

The accompanying tables form part of a larger work, entitled "Properties of Steam," in which the theory of steam and experimental methods of investigation are more fully discussed and illustrated. The principal formulæ and numerical results are here summarised, together with directions for using the diagram.

The tables are founded on experimental measurements: (1) of the specific heat of water and the mechanical equivalent; (2) of the specific heat of steam by the Author's continuous electric method; (3) of the adiabatic index with a compensated platinum thermometer; (4) of the Joule-Thomson cooling-effect with a differential throttling calorimeter.

The theory and results of these experiments were published in the *Proceedings of the Royal Society* and in the *Encyclopædia Britannica.** The properties of steam were represented by the simplest equations which could be chosen to satisfy the laws of thermodynamics, and at the same time to agree with experiment over the range required in practice. The theory was verified by calculating the values of the saturation pressure, which were found to agree with the observations of Regnault.

These equations constitute the only complete and consistent system hitherto proposed for steam. They have been adopted by Sir J. A. Ewing, F.R.S., by Professor W. E. Dalby, F.R.S., by Dr. Mollier of Dresden, and other well-known authorities. The experimental results have also been verified by the work of independent investigators. The consistency of the expressions makes it possible to tabulate the properties to a higher order of accuracy (·01° C.) than is usually attempted, without risk of introducing discrepancies in any of the thermodynamical relations. The absolute values are not known to this order of accuracy, but exactitude in the relative values is extremely

* *Proc. R.S.*, June, 1900, *Ency. Brit.*, 1902.

useful in solving problems relating to the discharge of steam, and in other cases where the result depends on small differences.

The notation adopted is that recommended for heat by the International Committee for Physico-Chemical Symbols, as revised and extended by the Physical Society of London.

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EXPLANATION OF THE TABLES.

Systems of Units.—Values are tabulated on the following three systems:—

F.P.C., or Foot-Pound-Centigrade, with pressure in pounds per square inch, volume in cubic feet per pound, and temperature on the Centigrade scale.

F.P.F., or Foot-Pound-Fahrenheit, with the same units of pressure and volume, but with temperature on the Fahrenheit scale.

K.M.C., or Kilogram-Metre-Centigrade, with pressure in kilos per sq. cm., volume in cubic metres per kilo, and temperature on the Centigrade scale.

Reduction Factors.—*The following Reduction Factors* are assumed for metric units :—

One Foot = 0·304800 Metre. One Pound = 0·453592 Kilogram,

which give the following factors for the derived units—

Density: 1 pound per cubic foot = 16·0184 kilograms per cubic metre.

Pressure: 1 pound per square inch = 0·070307 kilos per square centimetre.

Work: 1 Foot-Pound = 0·138255 Kilogram-Metre.

The Intensity of Gravity in London at sea-level is taken as the standard for the tables, and is assumed to be 1 in 2000 greater than the conventional value of the mean intensity in latitude 45°, namely 980·665 C.G.S., which gives

g = 9·8116 metres/sec.^{2} or 32·190 ft./sec.^{2} at London.

The Boiling-Point of Water, 100° C. or 212° F., is defined as the temperature of steam condensing under a pressure of one standard atmosphere, equivalent to 760 mm. of mercury at 0° C. at a place where g = 980·665 C.G.S.

1 Atmo. = 14·6890 pounds per sq. in., or 1·03274 kilos per sq. cm. (London).

Units of Heat.—The unit of heat on the F.P.C. system, with the pound as unit of mass, is the Pound-Calorie ; on the K.M.C.

system, the Kilo-Calorie. But the numbers representing Total Heat, etc., in pound-calories per pound are the same as those representing the same quantities in kilo-calories per kilogram. The total heat of water at 100° C. may be stated as 100 mean calories centigrade on either system, reckoned from 0° C.

The Mean Thermal Unit is adopted in these tables as the unit of heat. The mean thermal unit on the centigrade scale is 1/100th part of the quantity of heat required to raise unit mass of water under a pressure of 1 atmo. from 0° C. to 100° C. Similarly the unit of heat on the F.P.F. system is taken as the Mean British Thermal Unit, or B.Th.U., which is 1/180th part of the quantity of heat required to raise 1 lb. of water from 32° F. to 212° F.

Fundamental Constants for Water and Steam.—The following values, expressed in terms of the mean specific heat of water between the freezing- and boiling-points taken as unity, are the same in all three systems of units :—

Minimum Specific heat of water, $s = 0{\cdot}99666$
Gas Constant for Steam per unit mass, $R = 0{\cdot}11012$
Specific Heat of Steam at zero pressure, $S_0 = 0{\cdot}47719$
Ratio, $S_0/R = n + 1 = 13/3$. Index, $n = 10/3$

The following fundamental constants depend on the temperature scale :—

Latent Heat of Steam at B.P. $L = 539{\cdot}30°$ C. $= 970{\cdot}74°$ F.
Absolute temperature $T = t + 273{\cdot}10°$ C. $= t + 459{\cdot}58°$ F.

Values of the Mechanical Equivalent.—The absolute value of the mean gram-calorie C is taken as 4·1868 joules, or $4{\cdot}1868 \times 10^7$ C.G.S., from the results of experiments on the total heat h of water by the continuous electric and continuous mixture methods (*Phil. Trans.*, A. 199, pp. 57–148, 1902; A. 212, pp. 1–32, 1912).

The corresponding values of the equivalent J of the mean thermal unit in gravitational units of work for gravity at London are as follows :—

$J = 1400{\cdot}00$ (F.P.C.). $J = 777{\cdot}8$ (F.P.F.). $J = 426{\cdot}7$ (K.M.C.)

which must be increased by 1 in 2 000 for gravity in latitude 45°.

The reciprocal of J is denoted by A. The factor for reducing a product of dimensions PV to thermal units is denoted by a, and has the following values :—

$a = 144/1400$ (F.P.C.), $a = 144/777{\cdot}8$ (F.P.F.),
$a = 10000/426{\cdot}7$ (K.M.C.).

Expression for the Total Heat of Water h.

The effect of the ice molecules on the total heat near the freezing-point may be neglected in steam-engine work. The effect of the steam molecules in the liquid is most simply represented for water under saturation pressure by the equation—

$$h=st+vL/(V_s-v)-0{\cdot}003=st+(H_s-st)v/V_s-0{\cdot}003=H_s-L$$

where v and V_s are the volumes of water and dry saturated steam at t. H_s and L the total and latent heats.

The Entropy of Water under saturation pressure,

$$\phi = s \log_e (T/T_0) + vL/T(V_s - v) - 0{\cdot}000010$$

Expression for the Total Heat of Steam H.

The general expression, deduced from experiments on the specific heat S and the Joule-Thomson "Cooling-Effect," $C=(dT/dP)_H$ for dry steam in any state, is as follows :—

$$H = S_0T - SCP + B$$

where $S = S_0 + an(n+1)cP/T$, and $SC = a(n+1)c - b$.
B is a constant deduced from $L = 539{\cdot}30$ at 100° C., giving $B = 464{\cdot}00$ cals. C., or 835·20 B.Th.U./lb. F.

Characteristic Equation for Dry Steam giving V in terms of P and T.

$$V - b = RT/aP - c, \quad \text{where } c = c_1(T_1/T)^{10/3}.$$

$R/a=1{\cdot}07061$, $T_1=373{\cdot}10°$, $c_1=0{\cdot}4213$, $b=0{\cdot}01602$ (F.P.C.)
$R/a=0{\cdot}59479$, $T_1=671{\cdot}58°$, $c_1=0{\cdot}4213$, $b=0{\cdot}01602$ (F.P.F.)
$R/a=0{\cdot}004699$, $T_1=373{\cdot}10°$, $c_1=0{\cdot}02630$, $b=0{\cdot}00100$ (K.M.C.)

The "co-volume" b is taken as the volume of unit mass of water at 0° C., or 32° F.

The "co-aggregation volume" c is deduced from the cooling-effect C, and expresses the diminution of volume from the ideal value RT/aP due to co-aggregation or pairing of molecules. Values of c and V_s in cubic feet per pound are tabulated for each 1° C. in Table III. Values of V for dry steam in terms of T and P are given in Table V.

Expressions for E and H in terms of P and V for Dry Steam.

$$E = (10/3)aP(V - b) + B,$$
$$H = E + aPV = (13/3)aP(V - b) + abP + B$$

which gives for V in terms of H and P,

$$V = 3(H - B)/13aP + 10b/13,$$

whence $V = 2{\cdot}2436(H - 464)/P + 0{\cdot}0123$ (F.P.C.)
$V = 1{\cdot}2464(H - 835{\cdot}2)/P + 0{\cdot}0123$ (F.P.F.)
$V = 0{\cdot}009847(H - 464)/P + 0{\cdot}00077$ (K.M.C.)

General Expression for the Entropy Φ of Dry Steam at P and T.

$\Phi = 1\cdot09876 \log (T/T_1) - \cdot25356 \log (P/P_1) - ancP/T + 1\cdot76300$, where T_1P_1 are the values of T and P at the boiling-point. The Entropy is the same in all three systems of units.

Adiabatic or Isentropic Expansion of Dry Steam.

Adiabatic equation,

$$P(V-b)^{1\cdot3} = \text{constant}, \quad \text{or } P(V-b)/T = \text{constant},$$
$$\text{or } P/T^{13/3} = \text{constant}, \quad \text{or } (V-b)T^{10/3} = \text{constant}.$$

Heat-drop from H_0, P_0, V_0, T_0, in Isentropic Expansion of Dry Steam.

$$(H_0 - H)_\Phi = (13/3)aP_0(V_0 - b)(1 - (P/P_0)^{3/13}) + ab(P_0 - P),$$
$$= (H_0 - B - abP_0)(1 - T/T_0) + ab(P_0 - P).$$

General Expression for Velocity U due to Heat-drop.

$$U = (2Jg)^{1/2}(H_0 - H)^{1/2},$$

which gives $U = 300\cdot2(H_0 - H)^{1/2}$ ft./sec. (F.P.C.)
or $U = 223\cdot8(H_0 - H)^{1/2}$ ft./sec. (F.P.F.)
or $U = 91\cdot51(H_0 - H)^{1/2}$ m./sec. (K.M.C.)

Cross-section X of a Nozzle for Discharge of Mass M per second.

$X(\text{in.}^2) = 144MV/U$ (F.P.C. or F.),
$X(\text{cm.}^2) = 10\,000MV/U$, (K.M.C.)

Discharge M/X_t through a Nozzle per Unit Area of Throat X_t.

$M/X_t(\text{lbs./sec.in.}^2) = 0\cdot3155(1 + 0\cdot274b/V_0)(P_0/V_0)^{1/2}$, (F.P.C. or F.)
$M/X_t(\text{Kg./sec. cm.}^2) = 0\cdot2090(1 + 0\cdot274b/V_0)(P_0/V_0)^{1/2}$ (K.M.C.)
Throat Pressure, $P_t/P_0 = 0\cdot5457 - 0\cdot139b/V_0$.

(The b terms may be omitted in all the above formulæ unless V is small.)

Approximate Formula for Volume V_s of Dry Saturated Steam.

$pV_s^{16/15} = 490$ (F.P.C. or F.), $pV_s^{16/15} = 1\cdot786$ (K.M.C.)

whence Discharge of Steam, initially dry and saturated, without condensation in the supersaturated state,

$M/X_t = 0\cdot01730P_0^{31/32}$ (F.P.C. or F.),
$M/X_t = 0\cdot01593P_0^{31/32}$ (K.M.C.).

Approximate Equation (Zeuner) for Adiabatics of Wet Steam.

$pV^{1\cdot035 + 0\cdot1q} =$ constant, where $q =$ initial dryness fraction, whence Discharge of Steam initially dry, but with reversible condensation, according to the above formula,

$$P_t/P_0 = 0\cdot577,\ M/X_t = 0\cdot01646P_0^{31/32} \quad \text{(F.P.C. or F.)},$$
$$M/X_t = 0\cdot01516P_0^{31/32} \quad \text{(K.M.C.)}$$

Gibbs' Function or Potential, $G = T\Phi - H$, for Steam in any State.

For water or wet steam at t,

$$G_s = T\phi - h = T\Phi_s - H_s = sT \log_e (T/T_0) - st - 0\cdot003\ t/T_0,$$

a function of the temperature only, tabulated in Table III., p. 31, each 1° C.

The equation $T\Phi - H = G_s$, with H and Φ for dry steam, determines the saturation pressure p.

The relation $H = T\Phi - G_s$ is the exact equation for the adiabatics of wet steam when Φ is constant, giving H directly in terms of t and Φ. It may also be written in the forms,

$$H_s - H = T(\Phi_s - \Phi) = (1-q)L = (1-q)(H_s - st)(1 - v/V_s)$$
$$= (H_s - st)(V_s - V)/V_s,$$

where H_s, Φ_s, V_s, are for dry steam at t, and H, Φ, V, for wet steam. The expressions in terms of q are not required unless the hypothetical value of q is one of the given data, or unless a diagram is employed which gives q only in place of giving V directly. The expression for the adiabatic heat-drop $(H' - H'')_\Phi$, is obtained by taking the difference between the initial and final values of H.

$$(H' - H'')_\Phi = (t' - t'')\Phi' - (G' - G'') = H' - H_s'' + T''(\Phi_s'' - \Phi').$$

The first expression is general, and is most convenient for wet steam. The second applies only when the final state is wet.

Rankine Cycle, and Relative Efficiency F.

Thermal Equivalent AW of the work done in the cycle between limits p' and p''

$$AW = (H' - H'')_\Phi - a(p' - p'')v'' = (t' - t'')\Phi' - (G' - G'') - Aw$$

Heat supplied, $H' - h'' - Aw$. Efficiency, $AW/(H' - h'' - Aw)$, where $Aw = a(p' - p'')v''$. The "Efficiency Ratio" is the ratio of the indicated efficiency of the actual engine to that of the Rankine cycle between the same limits of t and p.

The "Relative Efficiency" F may be defined as the ratio of the indicated work per unit mass to the available work $J(H' - H'')_\Phi$ in isentropic flow with the same limits of t and p, which gives for the power and the consumption,

Indicated Horse-power	=	$2{\cdot}545MF(H' - H'')_\Phi$ (F.P.C.).
(M = mass-flow per sec.)		$1{\cdot}414MF(H' - H'')_\Phi$ (F.P.F.).
Indicated Kilowatts	=	$1{\cdot}548MF(H' - H'')_\Phi$ (K.M.C.).
Pounds per I.H.P. hour	=	$1414{\cdot}3/F(H' - H'')_\Phi$ (F.P.C.).
" " "	=	$2546/F(H' - H'')_\Phi$ (F.P.F.).
Kg. per Kilowatt hour	=	$860{\cdot}0/F(H' - H'')_\Phi$ (K.M.C.).

1 Kilowatt = 1·3403 Horse-Power (London) = 1·3597 Cheval-Vapeur (lat. 45°).

DESCRIPTION OF THE TABLES.

Table I. contains those properties of steam which are comparatively seldom required, and are tabulated only for each 10° C. of temperature in F.P.C. units. The quantities most often required, namely, p, ($\log p$), V, H, and G, are separately tabulated for each degree Centigrade (or Fahr.) in Table III., pp. 26–31, and are also given, together with the entropy Φ, in Table II., where the pressure is taken as argument, in all three systems of units. The use of the potential, $G = T\phi - h$, makes it unnecessary to employ h, ϕ, v, L, and L/T for finding the volume and the heat-drop in adiabatic expansion, and will be found to save a good deal of trouble in calculation.

If values of L are required for any other purpose, they may be found by interpolation, or may be directly calculated with less trouble from the formula, $L = (H - st)(1 - v/V)$.

The ratio v/V_s, which occurs as a small correction in the formula for the latent heat, L, and the heat of the liquid, h, may be taken for this purpose as $p/25\,000$, where p is the saturation pressure in lbs. per sq. in.

The wetness fraction, $(1 - q)$, if required very accurately, may be deduced by dividing the defect of total heat, $H_s - H_q$, from the saturation value by $H_s - st$, and adding the fraction v/V_s, or $0{\cdot}00004p$, of the result.

The quantity actually required in most cases is not the wetness, but the volume of the wet mixture, V_q, which is accurately deduced from H_q by the formula $V_q = V_s(H_q - st)/(H_s - st)$, without calculating q or making any correction for v, or for the variation of the specific heat.

The external work of vaporisation, $ap(V-v)$, and the intrinsic energy E, are very seldom required, but are easily found from the tables of p, V, and H.

The auxiliary quantities SC and $Z = anc/T$ are useful in calculating H and C, or Φ and S, respectively, but are also easily obtained from Table III., p. 29, giving c for each 1° C., so that it is unnecessary to tabulate them more fully. The specific heat S, and the cooling effect C, are so easily found from the table of total heat, that it is unnecessary to tabulate them separately, especially as their chief use is for calculating H.

Table II. contains the most important properties of saturated steam tabulated in terms of pressure for all three systems of units, and will be found the most useful table for general purposes. Except for pressures below 1 lb. per sq. in. (which are altogether omitted in many steam tables) the intervals of pressure are graduated so that the corresponding intervals of temperature shall never exceed 2° C. or fall below 1° C., which affords the most convenient scale for interpolation. The corresponding values of the pressure in kilos per sq. cm. in the second column are the exact equivalents to five significant figures of the pressures in lbs. per sq. in. in the first column. The values in both cases are for the latitude of London, and must be increased by 1 in 2 000 if it is required to express them in terms of the conventional value of gravity in latitude 45°. This correction may generally be neglected, since it does not affect the relative values, and is beyond the limit of accuracy of most observations. It should not in any case be applied to individual observations, but only as a final correction to the results of a series.

The values of the volume in the third and fourth columns are given to four significant figures, *i.e.* with a *minimum* accuracy of 1 in 2 000, corresponding to about 0·01° C. of temperature. More accurate values may be obtained, if required for small differences, from Table III., p. 28, for each 1° C. Owing to the great range of variation of the pressure and the volume, it is impossible to secure a uniform degree of proportionate accuracy in tabulating these quantities, except in the table of log p.

The values of the entropy in the fifth column are the same in all three systems of units. They are seldom required for small differences, and are often tabulated to three places of decimals only.

The values of t, H, and G, for saturated steam are tabulated in both Fahrenheit and Centigrade systems, to save the trouble

of reduction to or from the Fahrenheit scale, which is the most annoying feature of the British system of units. The values are given to 0·01° of temperature and 0·01 of a heat unit respectively, because t, H, and G are most often required for small differences, especially in deducing the heat-drop and velocity. It would for this reason be inconsistent to tabulate them (as in many other steam tables) with an order of accuracy inferior to that employed for the entropy.

The case of saturated steam is most completely covered for practical purposes by Table II., but the supplementary tables of p, log p, V, c, H, and G for each 1° C. will be found useful in cases where it is desired to solve, to the limit of accuracy, problems in which the elimination cannot be effected so that it is necessary to proceed by trial and interpolation, as is generally the case in the solution of transcendental equations. Quadratic and cubic empirical formulæ are often employed in preference to logarithmic with the idea of avoiding this difficulty; but the advantage gained is fictitious, because it is generally much easier to solve a logarithmic formula by interpolation, than to find the solution, even of a quadratic, without the aid of logarithms.

With the exception of the formulæ for the saturation pressure and entropy, which cannot possibly be put in any form except the logarithmic if they are to satisfy the second law of thermodynamics, the equations expressing the relations between the various properties of saturated steam are of the simplest possible algebraic type, involving no powers or roots, and exceptionally convenient for practical calculations as compared with the ordinary type of empirical formula involving powers of the temperature.

Tables for Superheated Steam.

The simplicity of the characteristic equation and the adiabatic equation for dry steam, makes it possible to solve the majority of problems for superheated or supersaturated steam as easily as for a perfect gas. Tabulation is superseded for many purposes by direct solution of the equations. The variation of specific heat is too large to neglect even in rough work, and it is a great advantage to be able to take exact account of the variation in so simple and consistent a manner. It is also possible to tabulate the values of the required quantities to a higher order of accuracy than is attainable with

empirical formulæ without risk of introducing inconsistencies in any of the thermodynamical relations. The tabulated values are useful chiefly in finding the initial state, when the final state is wet and the simple adiabatic for dry steam does not apply to the whole range of expansion. They are also useful in reducing experiments on the cooling effect, and other relations of superheated steam.

The majority of problems relating to superheated steam may be solved with sufficient approximation for practical purposes by the aid of the diagram. The tables serve chiefly as a method of verification, and supply more accurate values in problems where small differences are involved. The arrangement of the tables, with the scale of temperature on the left, and pressure along the top, is intended to correspond with the diagram. The practical limit of temperature in the use of superheated steam is in the neighbourhood of 400° C., which is comparatively seldom reached in the engine. The values tabulated for 450° and 500° C. are of theoretical rather than practical interest. Initial pressures below 50 lbs. are so uncommon, and below 20 lbs. so extremely rare, that close tabulation by steps of 1 lb. down to the lowest pressures (adopted in many steam tables) is quite superfluous in the case of superheated steam. The accuracy of the interpolation formulæ given below makes it unnecessary to tabulate the values for intervals of less than 10 lbs. in any part of the range. Intervals of 50 lbs. suffice at the upper limit of pressure.

Owing to the comparatively limited utility of tables for superheated steam, it has not been considered worth while to duplicate them in terms of the Fahrenheit scale and metric units of pressure. Values on either of these systems can be obtained very readily, if required, by the aid of the Fahrenheit scale of temperature on the left, and the kilogram scale of pressure at the top of each table. This arrangement has been found more convenient in practice than duplicating the tables.

In experimental tests, the practical datum is always the temperature and not the superheat. If the superheat only is given, the actual temperature of the steam must be found by adding the saturation temperature which is given for each pressure at the bottom of the column. The saturation line in each table is indicated by a zigzag rule. Values below this line represent the state of supersaturation, which is of great theoretical interest, though not permanently stable. These

values cannot occur as initial states, but only as transition states; and are useful chiefly for the purpose of estimating possible losses due to irreversible condensation, or changes of volume in rapid expansion which materially affect the discharge through orifices.

Table IV. Total Heat of Superheated Steam.

The most useful table for superheated steam is that of total heat H, which is the chief factor in determining the heat supply per unit mass of fluid. It is very easy to obtain accurate values of H by interpolation because the variation with pressure at constant temperature is small, and is accurately represented by the *constant* difference tabulated for 10 lbs. of pressure in the third column of the table. If the exact value of H is required at some intermediate pressure and temperature, it is generally best, for this reason, to find (1) two values of H at the given pressure for tabulated values of the temperature immediately above and below the required point, and (2) to interpolate between these for the required temperature. But for most purposes ample accuracy is secured by adding simultaneously the appropriate fractions of the pressure and temperature differences to the nearest tabulated value of H.

The table of H affords the most convenient method of finding the specific heat S at any point, or the mean specific heat over any range. Values of the mean specific heat for various ranges are often tabulated for calculating H when the superheat is given, but the opposite procedure is more accurate and convenient. The difference between any two adjacent values of H in the same vertical column is 10 times the specific heat S at the mean point, which is directly obtained to 3 significant figures. Thus the value of S at 500 lbs. and 245° C. is $(684{\cdot}01 - 677{\cdot}22)/10 = 0{\cdot}679$, and the mean value at the same pressure from 240° C. to 340° C. is $(739{\cdot}46 - 677{\cdot}22)/100 = 0{\cdot}6224$.

Another useful application of the table is to find the cooling effect C at any point, which is obtained by dividing the difference SC per pound, by the corresponding value of S obtained as already described. Thus to find C at 500 lbs. and 245° C., we have $SC = 0{\cdot}06122$ by interpolation from the difference column, $S = 0{\cdot}679$ already found, whence $C = 0{\cdot}0902°/\text{lb}$. Similarly at 50 lbs. and 150° C., $S = 0{\cdot}526$, $SC = 0{\cdot}1218$, $C = 0{\cdot}232°/\text{lb}$.

The drop of temperature for a large drop of pressure at

constant total heat, may be obtained by finding the temperature by interpolation at the lower pressure required to give the initial value of the total heat. Thus H at 200° and 200 lbs. is 673·07, which is the value given by interpolation at 170° and 22·69 lbs., or at 20 lbs. and 169·43°. It is very easy to trace lines of constant total heat in this way.

Tables V., VI., and VII. Interpolation for V, Φ, and G.

When the final state in adiabatic expansion is dry, T, H, and V are easily calculated from the adiabatic equation in the same way as for a perfect gas, but the required result may often be obtained with less trouble from the tables by interpolation, if exact values are required. When the final pressure P'' is given, find T'' by interpolation in Table VI. at P''. Thence find H'' by interpolation in Table IV., and deduce V'' from H'' and P'', or by interpolation in Table V.

Accurate values at any point intermediate between the tabulated values may generally be obtained with a small slide-rule by simple proportion in the usual way, provided that the differences involved are small, but this rule is insufficiently exact for some purposes in the case of V, Φ, and G, when the pressure differences are considerable. The following rule is *exact* in the case of V at constant temperature, for any pressure difference, however large.

If V', V'' are tabulated values of the volume at the same temperature T, corresponding to pressures P', P'' (of which P'' is the larger) to find the value of V at any pressure P intermediate between P' and P'', find the value of the difference $V' - V = (V' - V'')(P - P')/(P'' - P')$ by simple proportion in the usual way, increase it by the fraction $(P'' - P)/P$ of itself, and subtract the result from V'.

In the case of Φ and G a similar rule applies, but the corresponding difference, $\Phi' - \Phi$, or $G' - G$, found by simple proportion, must be increased by the fraction $(P'' - P)/2P$ of itself (with $2P$ in the denominator in place of P) before subtraction from Φ' or G'.

DESCRIPTION OF THE DIAGRAM.

The advantage of including all the required quantities in a single diagram, with a single logarithmic scale for both pressure and volume, is most readily secured by plotting the total heat as ordinate against the *logarithm* of the pressure as abscissa.

The scale of pressure employed is the familiar logarithmic scale of the 25-cm. slide-rule, which every student possesses, in which the ratio 100/1 is represented by 25 cms., and other ratios in proportion to their logarithms. The lines of constant pressure, the fundamental co-ordinate in the case of the steam engine, are vertical straight lines, of which very few need be drawn, since the pressures are read off with the slide-rule scale as easily as with a scale of equal parts, but with the additional advantage of uniform *proportionate* accuracy.

The lines of constant volume are slightly curved and inclined to the vertical, but the scale of volumes is so nearly the same as that of pressures in all parts of the diagram that the volumes can be read on the same logarithmic scale with nearly equal ease.

The saturation line, dividing the wet from the dry region, is nearly straight, and but slightly inclined to the horizontal.

The adiabatics, or lines of constant entropy, are diagonal curves (dotted) of nearly equal curvature and spacing, and are inclined at a favourable angle to the lines of constant pressure, temperature, volume, and total heat. In virtue of the fundamental relation $(dH/dp) = V$ at constant entropy, the adiabatics cross the saturation line without any abrupt change of direction, since the change of volume is continuous. By using a set-square with a curved diagonal, as described below, it is almost as easy to follow adiabatic expansion as in the entropy diagram, but the new diagram has the advantage that the initial and final pressures can be more accurately located.

The lines of constant dryness are easily drawn in the wet region, but a few only are inserted, because they are very seldom required when the volume and all the other quantities are shown *on one diagram.*

Lines of constant temperature are vertical straight lines in the wet region, but are not drawn, because it is easy to read the temperature, if required, from the scale of saturation temperature and pressure at the base of the diagram.

It should be observed that the horizontal lines of constant total heat and the vertical lines of constant pressure, are not closely ruled (as is customary) throughout the whole length and breadth of the diagram, but a few only are inserted as reference lines. The reason of this is that it is more expeditious and accurate in practice to read the values from the nearest reference line with a millimetre or logarithmic scale *placed on the diagram* than to refer continually to finely divided

scales at the side. The constant volume lines are ruled about twice as closely as the pressure lines, because the scale of volumes is not so accurately logarithmic. The temperature lines are ruled for each 20° in the dry region, to facilitate the use of a millimetre scale for interpolation, as the scale is very nearly 2° per mm. The entropy scale is T mms. per unit along a vertical in any part of the diagram, and is uniform along each vertical in the wet region.

Auxiliary Curves.—A curve of Latent Heat, L, is drawn in the wet region, from which the values of the latent heat at any pressure may be read on the total heat scale. This curve is useful in solving problems involving latent heat without reference to the tables. The heat of the liquid h, if required, may be found very accurately by adding to t the ordinate of the water-heat curve, given in the lower right-hand corner of the diagram. The curve of the thermodynamic potential of water $G = T\phi - h$, shown in the same region of the diagram, affords the most expeditious method of calculating the total heat of wet steam in any state by the formula $H = T\Phi - G$, when the temperature and entropy are given.

Method of Using the Diagram with Divided Set-Square.

Values sufficiently close for many purposes may be obtained by simple inspection, but in order to obtain accurate results from the diagram, it is most convenient to fix it on a drawing-board, adjusting it carefully so that the straight edge of the T-square is parallel to the horizontal lines of constant total heat. The T-square may be used to refer the reading of total heat at any point to a scale at the side, and a set-square may be employed to give the corresponding value of the pressure by the scale at the top. Or the distances on the diagram may be measured with a pair of dividers from the nearest reference lines, and read off on the millimetre and logarithmic scales of an ordinary 25-cm. slide-rule. But a more accurate and expeditious method is to employ a special set-square of transparent material, with a millimetre scale divided on its under side along the vertical edge, and a log. scale similarly divided along the horizontal edge. The millimetre scale serves for temperature and total heat, and the log. scale for pressure and volume. The diagonal edge of the set-square is curved to fit the mean adiabatic, and is useful for following adiabatic expansion, or finding the entropy.

To read the Entropy.—The only scale that is materially variable in different parts of the diagram is that of entropy. In order to meet this, without confusing the diagram by drawing too many lines, the insentropics or adiabatics are drawn only for each tenth of a unit of entropy from 1·4 to 2·1, and the scale of entropy is divided to hundredths along each of the vertical reference lines of the pressure scale. To find the numerical value of the entropy corresponding to any given point on the diagram, mark the required point with a fine pencil, find the part of the curved edge of the set-square (or of a paper template traced and cut to fit the mean adiabatic 1·7) which corresponds most nearly in curvature with the nearest adiabatic, set the curve to pass through the pencil dot and divide the entropy scales equally on either side. By estimating tenths of a division, the required value of the entropy can be found to 1, in the third place of decimals.

To read the Total Heat at any Point.—Read the vertical distance in mms. and tenths above the nearest reference line, and add the reading to the value marked on the reference line.

To measure the Heat-Drop between Two given Points.—Adjust the T-square to pass through the lower point, and slide the set-square until its vertical edge meets the upper point. The drop is given by the vertical scale reading in mms.; but unless the T-square and drawing-board are very perfect, it is usually better to measure each value of *H* from the nearest reference line, and take the difference.

To read the Pressure at any Point on the Diagram.—Place the set-square on the diagram with its vertical edge to the right, and the log. scale reading backwards from right to left, the divisions being on the under side. Slide the set-square along the T-square until its vertical edge passes through the required point. The pressure is then read on the log. scale at the point where it is crossed by the 1, 10, or 100 lb. reference lines of pressure. Thus if the pressure is 157 lbs., the 100 line will cross the scale at 1·57, or the 10 line at 15·7. Similarly, to mark a vertical line on the diagram for any given pressure, say 157 lbs., slide the set-square horizontally along the T-square to the right till the division 1·57 of the log. scale meets the edge of the 100-lb. line, and rule a short vertical line with a fine pencil along the vertical edge of the set-square near the required temperature or entropy. Since it is generally necessary to mark the pressure in this way with a short vertical line, it is

most convenient to have the log. scale reading backwards from right to left, which also suits best for reading volumes.

To read the Volume.—Lay the log. scale across the lines of constant volume so that the numbers correspond. Thus, if the volume is between 50 and 70, set the divisions 50 and 70, or 5 and 7, on the log. scale to fit as nearly as possible with the 50 and 70 lines of constant volume. The fit can usually be made exact by sloping the scale. If not, adjust the errors at either end of the 50 to 70 interval by estimation in the same proportion as the whole interval is divided by the required point. Read the required point on the scale, estimating tenths of a division as usual.

To read the Temperature for Superheated Steam.—Place the mm. scale across the lines of constant temperature so that the cm. divisions nearly fit. Adjust the small errors at either end, if any, proportionately to the division of the interval by the required point. Read the point in mms. and tenths. Multiply by 2, and add the result to the temperature marked on the lower line.

To mark the State-point, given P and T for Superheated Steam.—Set the vertical edge of the set-square for the required pressure, slide the square vertically till the cm. divisions fit the lines of constant temperature near the required point, mark the required temperature with a fine pencil dot by the aid of the mm. scale.

To mark the Final State-Point, given P and Φ.—Rule a short vertical for the final P to cross the adiabatic. Adjust the curved edge of the set-square to the value of Φ as previously explained, and mark the required point with a dot, or by ruling a short piece of the adiabatic. Or conversely, rule a short piece of the adiabatic, and mark the required pressure on it.

To find P and H, when V and Φ *are given.*—Rule a short piece of the adiabatic, adjust the log. scale to fit the lines of constant volume, and cross the adiabatic at the given value of *V*. Hold a pencil or a divider point at the crossing while shifting the set-square so that its vertical edge rests against the point and its horizontal edge fits the nearest reference line of *H*. Read the vertical scale for *H* at the point, and the log. scale for *P* where it crosses the 1, 10, or 100 line.

To read the Temperature for Saturated Steam at any Pressure.—Reverse the log. scale to read from left to right, and lay it along the temperature scale at the base of the diagram. To find h for the liquid, add the ordinate of the $h - t$ curve to the value of t.

TABLE I.—AUXILIARY TABLE FOR SATURATED STEAM OF QUANTITIES SELDOM REQUIRED, IN TERMS OF TEMPERATURE CENTIGRADE IN FOOT-POUND UNITS. (F.P.C.)

t	h	L	AW	E	ϕ	Φ	v	SC	$100\,Z$
0	0	594·27	30·063	564·21	0	2·17602	0·01602	0·5295	1·496
10	9·98	589·03	31·156	567·85	0·03585	2·11649	0·01603	0·4695	1·280
20	19·94	583·78	32·243	571·48	0·07046	2·06221	0·01605	0·4181	1·102
30	29·91	578·49	33·324	575·07	0·10393	2·01247	0·01609	0·3736	0·9526
40	39·89	573·15	34·395	578·64	0·13631	1·96688	0·01614	0·3351	0·8275
50	49·88	567·75	35·455	582·17	0·16770	1·92490	0·01621	0·3016	0·7221
60	59·87	562·29	36·498	585·66	0·19815	1·88621	0·01629	0·2723	0·6327
70	69·88	556·72	37·523	589·07	0·22774	1·85039	0·01638	0·2466	0·5566
80	79·90	551·05	38·526	592·41	0·25652	1·81712	0·01648	0·2240	0·4914
90	89·94	545·25	39·502	595·67	0·28454	1·78619	0·01659	0·2039	0·4354
100	100·00	539·30	40·448	598·83	0·31186	1·75732	0·01671	0·1861	0·3871
110	110·09	533·17	41·361	601·86	0·33853	1·73027	0·01684	0·1703	0·3452
120	120·22	526·85	42·236	604·78	0·36460	1·70485	0·01698	0·1561	0·3087
130	130·40	520·32	43·072	607·58	0·39011	1·68092	0·01713	0·1435	0·2768
140	140·62	513·57	43·864	610·23	0·41511	1·65831	0·01729	0·1321	0·2489
150	150·91	506·56	44·611	612·73	0·43963	1·63689	0·01746	0·1219	0·2245
160	161·26	499·29	45·311	615·08	0·46373	1·61657	0·01765	0·1126	0·2029
170	171·69	491·75	45·962	617·27	0·48743	1·59724	0·01785	0·1042	0·1838
180	182·21	483·93	46·564	619·30	0·51078	1·57884	0·01807	0·0966	0·1668
190	192·83	475·82	47·115	621·19	0·53381	1·56128	0·01831	0·0897	0·1517
200	203·55	467·41	47·617	622·91	0·55654	1·54453	0·01856	0·0834	0·1383
210	214·40	458·69	48·070	624·48	0·57904	1·52851	0·01885	0·0777	0·1263
220	215·37	449·69	48·474	625·93	0·60128	1·51326	0·01914	0·0725	0·1156
230	236·49	440·38	48·831	627·23	0·62332	1·49868	0·01946	0·0677	0·1060
240	247·74	430·81	49·147	628·43	0·64517	1·48480	0·01980	0·0633	0·0973
250	259·16	420·96	49·419	629·53	0·66687	1·47161	0·02016	0·0592	0·0895

NOTATION AND FORMULÆ FOR THE VARIOUS QUANTITIES IN TABLE I.

h = Total Heat of Water under saturation pressure p, in mean calories Centigrade.
$= st + vL/(V - v) = st + (H - st)v/V = H - L$, in which the symbols denote :—
H = Total Heat of Dry Steam at p, in mean calories Centigrade $= S_0T - SCp + 464$.
s = Minimum Specific Heat of Water = 0·99666. $st = t - t/300$.
v = Volume of Water, V = Volume of Dry Steam, at p in cubic feet per pound.
The Ratio $v/V = p/25\,000$ (nearly) if p is in pounds per sq. inch absolute.
L = Latent Heat of Steam in mean calories Centigrade $= (H - st)(1 - v/V)$.
AW = Thermal Equivalent in mean calories Centigrade of External Work of Vaporisation W.
$= ap(V - v)$, where $A = 1/J = 1/1400$, and $a = 144/1400$, for (F.P.C.) units.
E = Intrinsic Energy of Dry Steam at p in mean cals. C. $= H - apV = anp(V - b) + 464$.
ϕ = Entropy of Water at p in cals./deg. $= s \log_e(T/273{\cdot}1) + vL/T(V - v)$.
Φ = Entropy of Dry Steam at p in cals./deg. $= \phi + L/T$.
SC = Product of Specific Heat S of Steam and Cooling Effect C, in cals. per lb. pressure.
$= a(n + 1)c - ab$, where $b = v_0 = 0{\cdot}01602$, $c = 0{\cdot}4213(373{\cdot}1/T)^n$, and $n = 10/3$.
$Z = anc/T$. $S = S_0 + (n + 1)Zp$. $S_0 = 0{\cdot}47719 = (n + 1)R$. $R = 0{\cdot}11012$ mean cals./deg.

TABLE II.—PROPERTIES OF SATURATED STEAM IN TERMS OF PRESSURE (p) FOR KILOGRAMMETRE AND FOOT-POUND UNITS, CENTIGRADE AND FAHRENHEIT. (K.M.C.), (F.P.C.), and (F.P.F.)

Pressure p.		Volume V.		Entropy Φ	Temperature t, Total heat H, and Potential G.					
					Centigrade units.			Fahrenheit units.		
Pounds / Sq. in.	Kilos / Sq. cm.	Cu. ft. / Pound	Cu. m. / Kilo.	C. or F.	t	H	G	t	H	G
0·08922	0·00627	3276	204·5	2·1760	0°	594·27	0	32°	1069·70	0
0·1	0·00703	2940	183·5	2·1662	1·59	595·03	0·005	34·86	1071·06	0·009
0·2	0·01406	1524	95·17	2·1068	11·69	599·81	0·246	53·04	1079·66	0·443
0·3	0·02109	1038	64·78	2·0727	17·99	602·77	0·58	64·38	1084·99	1·04
0·4	0·02812	790·7	49·36	2·0482	22·66	604·97	0·91	72·79	1088·95	1·64
0·5	0·03515	650·5	40·61	2·0299	26·41	606·73	1·23	79·54	1092·12	2·21
0·6	0·04218	539·1	33·66	2·0148	29·54	608·19	1·53	85·17	1094·74	2·75
0·7	0 04921	466·2	29·11	2·0018	32·25	609·44	1·82	90·05	1096·99	3·28
0·8	0·05625	411·1	25·66	1·9906	34·65	610·55	2·10	94·36	1098·99	3·78
0·9	0·06328	367·9	22·97	1·9810	36·83	611·58	2·37	98·30	1100·84	4·27
1·0	0·07031	333·1	20·79	1·9724	38·74	612·46	2·61	101·74	1102·43	4·70
1·1	0·07734	304·5	19·01	1·9646	40·52	613·28	2·85	104·94	1103·90	5·13
1·2	0·08437	280·6	17·52	1·9575	42·17	614·04	3·08	107·91	1105·27	5·54
1·3	0·09140	260·2	16·24	1·9509	43·71	614·75	3·31	110·68	1106·55	5·96
1·4	0·09843	242·7	15·15	1·9449	45·14	615·41	3·52	113·25	1107·74	6·33
1·5	0·10546	227·4	14·19	1·9392	46·49	616·02	3·73	115·69	1108·84	6·71
1·6	0·11249	214·0	13·36	1·9339	47·77	616·61	3·93	117·98	1109·90	7·08
1·7	0·11952	202·2	12·63	1·9290	48·98	617·16	4·13	120·17	1110·89	7·44
1·8	0·12655	191·6	11·96	1·9244	50·13	617·69	4·32	122·23	1111·85	7·78
1·9	0·13358	182·1	11·37	1·9200	51·22	618·19	4·51	124·20	1112·74	8·12
2·0	0·14061	173·5	10·83	1·9159	52·27	618·67	4·69	126·08	1113·61	8·45
2·2	0·15468	158·7	9·906	1·9081	54·24	619·55	5·03	129·64	1115·20	9·06
2·4	0·16874	146·4	9·140	1·9010	56·06	620·36	5·37	132·92	1116·65	9·67
2·6	0·18280	135·6	8·466	1·8947	57·75	621·14	5·69	135·94	1118·05	10·24
2·8	0·19686	126·5	7·897	1·8888	59·34	621·86	6·00	138·82	1119·35	10·80
3·0	0·21092	118·6	7·401	1·8833	60·83	622·53	6·30	141·50	1120·56	11·34
3·2	0·22498	111·6	6·967	1·8780	62·24	623·16	6·58	144·04	1121·69	11·84
3·4	0·23904	105·4	6·582	1·8731	63·58	623·76	6·86	146·44	1122·77	12·35
3·6	0·25311	99·93	6·238	1·8685	64·85	624·32	7·13	148·73	1123·78	12·83
3·8	0·26717	95·00	5·930	1·8641	66·07	624·87	7·39	150·92	1124·77	13·30
4·0	0·28123	90·54	5·652	1·8600	67·23	625·38	7·64	153·01	1125·69	13·75

$T = t + 273{\cdot}10°$ Centigrade. $T = t + 459{\cdot}58°$ Fahrenheit. $G = T\Phi - H$.

Adiabatic Heat-Drop. $H' - H'' = (t' - t'')\Phi' - (G'_1 - {}_1G'') = (H' - H''_s) + T''(\Phi''_s - \Phi')$.

The suffix $_s$ in H_s, V_s, or Φ_s denotes the tabulated saturation value at t or p.

To find H and V for wet steam, given Φ, and t or p,

$H_s - H = T(\Phi_s - \Phi)$, or $H = T\Phi - G$,

$V_s - V = V_s(H_s - H)/(H_s - st)$ Cent. $= V_s(H_s - H)/(H_s - s(t - 32))$ Fahr.

TABLE II.—PROPERTIES OF SATURATED STEAM IN TERMS OF PRESSURE (p) FOR KILOGRAMMETRE AND FOOT-POUND UNITS, CENTIGRADE AND FAHRENHEIT.

Pressure p.		Volume V.		Entropy Φ	Temperature t, Total heat H, and Potential G.					
					Centigrade units.			Fahrenheit units.		
Pounds / Sq. in.	Kilos / Sq. cm.	Cu. ft. / Pound	Cu. m. / Kilo	C. or F.	t	H	G	t	H	G
4·0	0·28123	90·54	5·652	1·8600	67·23	625·38	7·64	153·01	1125·69	13·75
4·2	0·29529	86·50	5·400	1·8561	68·34	625·87	7·89	155·01	1126·57	14·20
4·4	0·30935	82·80	5·169	1·8524	69·40	626·34	8·12	156·92	1127·41	14·62
4·6	0·32341	79·42	4·958	1·8489	70·43	626·79	8·36	158·77	1128·23	15·05
4·8	0·33747	76·31	4·764	1·8455	71·42	627·22	8·59	160·55	1129·00	15·46
5·0	0·35154	73·44	4·585	1·8422	72·38	627·64	8·81	162·28	1129·75	15·86
5·2	0·36560	70·80	4·420	1·8391	73·30	628·03	9·03	163·94	1130·46	16·25
5·4	0·37966	68·34	4·266	1·8361	74·19	628·42	9·25	165·54	1131·16	16·65
5·6	0·39372	66·05	4·123	1·8331	75·06	628·81	9·46	167·11	1131·86	17·03
5·8	0·40778	63·91	3·990	1·8303	75·90	629·17	9·66	168·62	1132·51	17·39
6·0	0·42184	61·91	3·865	1·8277	76·72	629·52	9·86	170·09	1133·15	17·75
6·5	0·45700	57·44	3·586	1·8214	78·67	630·37	10·34	173·60	1134·67	18·61
7·0	0·49215	53·59	3·346	1·8156	80·49	631·15	10·81	176·88	1136·07	19·46
7·5	0·52730	50·24	3·136	1·8101	82·21	631·88	11·25	179·98	1137·38	20·25
8·0	0·56246	47·30	2·953	1·8049	83·84	632·57	11·69	182·91	1138·63	21·04
8·5	0·59761	44·69	2·790	1·8001	85·38	633·23	12·10	185·68	1139·82	21·78
9·0	0·63276	42·36	2·644	1·7956	86·84	633·85	12·50	188·31	1140·94	22·50
9·5	0·66792	40·27	2·520	1·7914	88·24	634·44	12·89	190·84	1141·99	23·20
10·0	0·70307	38·39	2·397	1·7874	89·58	635·01	13·26	193·25	1143·02	23·87
10·5	0·73822	36·68	2·290	1·7836	90·87	635·54	13·63	195·57	1143·98	24·54
11·0	0·77338	35·11	2·192	1·7799	92·10	636·05	13·99	197·78	1144·89	25·18
11·5	0·80853	33·68	2·103	1·7765	93·29	636·55	14·33	199·92	1145·79	25·79
12·0	0·84368	32·37	2·021	1·7731	94·44	637·02	14·67	201·99	1146·64	26·40
12·5	0·87884	31·15	1·945	1·7699	95·55	637·47	15·00	203·99	1147·45	27·00
13·0	0·91399	30·03	1·875	1·7669	96·62	637·91	15·32	205·92	1148·24	27·57
13·5	0·94914	28·99	1·810	1·7640	97·66	638·35	15·63	207·78	1149·03	28·13
14·0	0·98430	28·02	1·749	1·7611	98·66	638·77	15·94	209·59	1149·80	28·69
14·5	1·0195	27·11	1·693	1·7584	99·64	639·16	16·25	211·34	1150·49	29·25
14·689	1·0327	26·79	1·672	1·7573	100°	639·30	16·36	212°	1150·74	29·45
15·0	1·0546	26·27	1·640	1·7557	100·58	639·53	16·54	213·05	1151·16	29·77
16·0	1·1249	24·73	1·544	1·7506	102·41	640·26	17·12	216·34	1152·48	30·82
17·0	1·1952	23·37	1·459	1·7458	104·14	640·95	17·68	219·46	1153·72	31·82
18·0	1·2655	22·16	1·383	1·7414	105·79	641·60	18·20	222·42	1154·88	32·76
19·0	1·3358	21·06	1·315	1·7372	107·36	642·22	18·72	225·24	1156·00	33·69
20·0	1·4061	20·08	1·253	1·7333	108·87	642·82	19·22	227·97	1157·08	34·59

$T = t + 273{\cdot}10°$ Centigrade. $T = t + 459{\cdot}58°$ Fahrenheit. $G = T\Phi - H$.

Adiabatic Heat-Drop. $H' - H'' = (t' - t'')\,\Phi' - (G' - G'') = (H' - H''_s) + T''(\Phi''_s - \Phi')$.

The suffix $_s$ in H_s, V_s, or Φ_s denotes the tabulated saturation value at t or p.

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Pressure p.		Volume V.		Eutropy Φ C. or F.	Temperature t, Total heat H, and Potential G.					
					Centigrade units.			Fahrenheit units.		
Pounds / Sq. in.	Kilos / Sq. cm.	Cu. ft. / Pound	Cu. m. / Kilo		t	H	G	t	H	G
20	1·4061	20·08	1·253	1·7333	108·87	642·82	19·22	227·97	1157·08	34·59
21	1·4764	19·18	1·197	1·7294	110·32	643·39	19·71	230·58	1158·10	35·48
22	1·5468	18·37	1·147	1·7258	111·71	643·92	20·18	233·08	1159·06	36·32
23	1·6171	17·62	1·100	1·7223	113·05	644·43	20·64	235·49	1159·98	37·15
24	1·6874	16·93	1·057	1·7189	114·34	644·93	21·09	237·81	1160·88	37·96
25	1·7577	16·29	1·017	1·7157	115·59	645·39	21·53	240·06	1161·70	38·75
26	1·8280	15·71	0·9801	1·7126	116·80	645·85	21·95	242·24	1162·53	39·51
27	1·8983	15·16	0·9464	1·7097	117·97	646·32	22·37	244·35	1163·38	40·27
28	1·9686	14·66	0·9149	1·7069	119·11	646·74	22·78	246·40	1164·14	41·00
29	2·0389	14·18	0·8854	1·7042	120·21	647·15	23·18	248·38	1164·88	41·72
30	2·1092	13·74	0·8577	1·7016	121·28	647·54	23·56	250·30	1165·58	42·41
31	2·1795	13·33	0·8319	1 6991	122·33	647·92	23·95	252·19	1166·26	43·11
32	2·2498	12·94	0·8076	1·6966	123·35	648·30	24·33	254·03	1166·94	43·79
33	2·3201	12·57	0·7847	1·6943	124·33	648·66	24·69	255·79	1167·60	44·44
34	2·3904	12·22	0·7631	1·6919	125·31	649·02	25·07	257·56	1168·24	45·12
35	2·4607	11·90	0·7426	1·6897	126·25	649·36	25·43	259·25	1168·86	45·77
36	2·5311	11·59	0·7234	1·6874	127·17	649·69	25·77	260·91	1169·44	46·38
37	2·6014	11·29	0·7051	1·6852	128·07	650·02	26·12	262·52	1170·04	47·01
38	2·6717	11·02	0·6876	1·6831	128·96	650·34	26·45	264·13	1170·61	47·61
39	2·7420	10·75	0·6711	1·6811	129·82	650·65	26·79	265·67	1171·17	48·22
40	2·8123	10·50	0·6554	1·6792	130·67	650·95	27·12	267·21	1171·71	48·81
42	2·9529	10·03	0·6261	1·6754	132·31	651·53	27·76	270·16	1172·76	49 97
44	3·0935	9·603	0·5994	1·6719	133·89	652·08	28·40	273·00	1173·74	51·12
46	3·2341	9·212	0·5750	1·6685	135·41	652·61	29·00	275·74	1174·70	52·20
48	3·3747	8·853	0·5527	1·6651	136·88	653·12	29·59	278·38	1175·62	53·26
50	3·5154	8·520	0·5319	1·6620	138·30	653·60	30·16	280·94	1176·48	54·29
52	3·6560	8·213	0·5127	1·6589	139·67	654·08	30·72	283·41	1177·35	55·29
54	3·7966	7·928	0·4949	1·6561	141·01	654·53	31·27	285·82	1178·15	56·28
56	3·9372	7·663	0·4784	1·6533	142·31	654·95	31·81	288·16	1178·91	57·26
58	4·0778	7·415	0·4629	1·6506	143·57	655·37	32·34	290·42	1179·67	58·21
60	4·2184	7·184	0·4485	1·6479	144·79	655·77	32·85	292·61	1180·39	59·13
62	4·3590	6·966	0·4348	1·6453	145·98	656·16	33·36	294·76	1181·08	60·05
64	4·4996	6·761	0·4221	1·6429	147·14	656·55	33·86	296·85	1181·79	60 95
66	4·6402	6·571	0·4102	1·6405	148·27	656·91	34·34	298·88	1182·44	61·81
68	4·7809	6·388	0·3988	1·6382	149·38	657·26	34·82	300·88	1183·07	62·68
70	4·9215	6·218	0·3882	1·6359	150·46	657·61	35·30	302·83	1183·70	63·54

To find H and V for wet steam, given Φ, and t or p,

$H_s - H = T(\Phi_s - \Phi)$, or $H = T\Phi - G$.

$V_s - V = V_s(H_s - H)/(H_s - st)$ Cent. $= V_s(H_s - H)/(H_s - s(t - 32))$ Fahr.

TABLE II.—PROPERTIES OF SATURATED STEAM IN TERMS OF PRESSURE (p) FOR KILOGRAMMETRE AND FOOT-POUND UNITS, CENTIGRADE AND FAHRENHEIT.

Pressure p.		Volume V.		Entropy	Temperature t, Total heat H, and Potential G.					
				Φ	Centigrade units.			Fahrenheit units.		
Pounds Sq. in.	Kilos Sq. cm.	Cu. ft. Pound	Cu. m. Kilo	C. or F.	t	H	G	t	H	G
70	4·9215	6·218	0·3882	1·6359	150·46	657·61	35·30	302·83	1183·70	63·54
72	5·0621	6·056	0·3781	1·6337	151·51	657·94	35·76	304·72	1184·29	64·36
74	5·2027	5·902	0·3685	1·6315	152·55	658·28	36·22	306·60	1184·90	65·18
76	5·3433	5·757	0·3594	1·6294	153·56	658·59	36·67	308·40	1185·46	66·01
78	5·4839	5·618	0·3507	1·6275	154·55	658·90	37·11	310·19	1186·03	66·80
80	5·6246	5·487	0·3425	1·6256	155·52	659·20	37·54	311·93	1186·56	67·57
82	5·7652	5·362	0·3348	1·6237	156·47	659·49	37·97	313·65	1187·08	68·34
84	5·9058	5·241	0·3272	1·6218	157·40	659·77	38·39	315·32	1187·59	69·10
86	6·0464	5·127	0·3201	1·6200	158·32	660·06	38·81	316·98	1188·11	69·85
88	6·1870	5·018	0·3133	1·6183	159·22	660·33	39·22	318·60	1188·60	70·60
90	6·3276	4·913	0·3067	1·6165	160·09	660·59	39·62	320·16	1189·06	71·30
92	6·4682	4·813	0·3004	1·6148	160·96	660·85	40·02	321·73	1189·53	72·04
94	6·6088	4·717	0·2945	1·6131	161·82	661·11	40·42	323·28	1190·00	72·76
96	6·7495	4·624	0·2887	1·6115	162·66	661·35	40·81	324·79	1190·43	73·46
98	6·8901	4·535	0·2831	1·6098	163·48	661·59	41·20	326·26	1190·86	74·16
100	7·0307	4·451	0·2779	1·6082	164·28	661·82	41·58	327·70	1191·28	74·84
105	7·3822	4·251	0·2654	1·6044	166·25	662·38	42·50	331·25	1192·29	76·50
110	7·7338	4·070	0·2541	1·6007	168·15	662·93	43·40	334·67	1193·27	78·12
115	8·0853	3·903	0·2437	1·5972	169·98	663·44	44·28	337·96	1194·19	79·70
120	8·4368	3·751	0·2342	1·5938	171·75	663·92	45·13	341·15	1195·06	81·22
125	8·7884	3·609	0·2254	1·5906	173·47	664·40	45·97	344·25	1195·92	82·75
130	9·1399	3·479	0·2172	1·5875	175·13	664·83	46·78	347·23	1196·69	84·20
135	9·4914	3·358	0·2096	1·5846	176·74	665·27	47·59	350·13	1197·49	85·66
140	9·8430	3·245	0·2026	1·5818	178·31	665·69	48·37	352·96	1198·24	87·07
145	10·195	3·140	0·1960	1·5791	179·83	666·10	49·13	355·69	1198·98	88·44
150	10·546	3·041	0·1898	1·5765	181·31	666·49	49·89	358·36	1199·68	89·80
155	10·898	2·949	0·1841	1·5740	182·75	666·86	50·62	360·95	1200·35	91·12
160	11·249	2·862	0·1787	1·5715	184·16	667·22	51·34	363·48	1200·99	92·41
165	11·601	2·781	0·1736	1·5691	185·54	667·56	52·05	365·97	1201·61	93·69
170	11·952	2·703	0·1687	1·5666	186·88	667·90	52·75	368·39	1202·22	94·95
175	12·304	2·631	0·1642	1·5643	188·19	668·22	53·43	370·74	1202·79	96·17
180	12·655	2·562	0·1600	1·5620	189·48	668·53	54·10	373·06	1203·35	97·38
185	13·007	2·496	0·1558	1·5598	190·74	668·83	54·77	375·33	1203·89	98·59
190	13·358	2·435	0·1520	1·5577	191·97	669·13	55·42	377·55	1204·44	99·76
195	13·710	2·376	0·1483	1·5557	193·18	669·41	56·07	379·72	1204·94	100·93
200	14·061	2·320	0·1448	1·5538	194·35	669·69	56·69	381·83	1205·44	102·04

$T = t + 273{\cdot}10°$ Centigrade. $T = t + 459{\cdot}58°$ Fahrenheit. $G. = T\Phi - H.$

Adiabatic Heat-Drop. $H' - H'' = (t' - t'')\Phi' - (G' - G'') = (H' - H''_s) + T''(\Phi''_s - \Phi').$

The suffix $_s$ in H_s, V_s, or Φs denotes the tabulated saturation value at t or p.

TABLE II.—PROPERTIES OF SATURATED STEAM IN TERMS OF PRESSURE (p) FOR KILOGRAMMETRE AND FOOT-POUND UNITS, CENTIGRADE AND FAHRENHEIT.

Pressure p.		Volume V.		Entropy	Temperature t, Total heat H, and Potential G.					
				Φ	Centigrade units.			Fahrenheit units.		
Pounds / Sq. in.	Kilos / Sq. cm.	Cu. ft. / Pound	Cu. m. / Kilo	C. or F.	t	H	G	t	H	G
200	14·061	2·320	0·1448	1·5538	194·35	669·69	56·69	381·83	1205·44	102·04
205	14·413	2·266	0·1415	1·5520	195·52	669·95	57·32	383·94	1205·91	103·18
210	14·764	2·216	0·1383	1·5502	196·66	670·20	57·94	385·98	1206·36	104·29
215	15·116	2·167	0·1353	1·5483	197·77	670·46	58·53	387·98	1206·83	105·35
220	15·468	2·120	0 1324	1·5465	198·87	670·70	59·13	389·97	1207·26	106·43
225	15·819	2·076	0·1296	1·5447	199·95	670·95	59·72	391·91	1207·71	107·50
230	16·171	2·034	0·1270	1·5429	201 02	671·19	60·31	393·84	1208·14	108·56
235	16·522	1·993	0·1244	1·5412	202·06	671·42	60·88	395·71	1208·56	109·58
240	16·874	1·954	0·1220	1·5395	203·09	671·64	61·45	397·56	1208·95	110·61
245	17·225	1·916	0·1196	1 5379	204·10	671·86	62·02	399·38	1209·35	111·63
250	17·577	1·880	0·1173	1·5362	205·10	672·07	62·58	401·18	1209·73	112·64
260	18·280	1·811	0·1131	1·5332	207·04	672·48	63·66	404·67	1210·47	114·59
270	18·983	1·748	0·1091	1·5303	208·93	672·88	64·72	408·08	1211·18	116·49
280	19·686	1·689	0·1055	1·5274	210·77	673·25	65·77	411·39	1211·85	118·38
290	20·389	1·634	0 1020	1·5246	212·57	673·61	66·79	414·63	1212·50	120·22
300	21·092	1·583	0·0988	1·5219	214·32	673·96	67·80	417·78	1213·13	122·04
310	21·795	1·534	0·0958	1·5192	216·02	674·29	68·79	420·84	1213·72	123·82
320	22·498	1·489	0·0930	1·5167	217·68	674·62	69·75	423·82	1214·32	125·55
330	23·201	1·446	0·0903	1·5142	219·30	674·93	70·70	426·74	1214·88	127·26
340	23·904	1·406	0·0878	1·5109	220·89	675·23	71·64	429·60	1215·41	128·95
350	24·607	1·368	0·0854	1·5096	222·45	675·52	72·57	432·41	1215·94	130·63
360	25·311	1·333	0·0832	1 5074	223·97	675·80	73·47	435·15	1216·44	132·24
370	26·014	1·298	0·0811	1·5053	225·45	676·07	74·36	437·81	1216·93	133·85
380	26·717	1·266	0·0790	1·5032	226·91	676·34	75·24	440·44	1217·41	135·43
390	27·420	1·235	0·0771	1·5012	228·34	676·59	76·09	443·01	1217·86	136·96
400	28·123	1·206	0·0753	1·4991	229·75	676·84	76·96	445·55	1218·32	138·53
410	28·826	1·178	0·0736	1·4971	231·13	677·07	77·80	448·04	1218·73	140·04
420	29·529	1·152	0·0719	1·4952	232·49	677·30	78·63	450·49	1219·14	141·53
430	30·232	1·127	0·0703	1·4933	233·82	677·53	79·44	452·88	1219·55	142·99
440	30·935	1·102	0·0688	1·4915	235·13	677·76	80·26	455·23	1219·97	144·46
450	31·638	1·079	0·0674	1·4897	236·42	677·97	81·06	457·55	1220·35	145·90
460	32·341	1·057	0·0660	1·4880	237·69	678·18	81·85	459·84	1220·73	147·33
470	33·044	1·036	0·0647	1·4863	238·93	678·38	82·63	462·08	1221·09	148·73
480	33·747	1·016	0·0634	1·4846	240·16	678·58	83·40	464·29	1221·44	150·12
490	34·450	0·996	0·0622	1·4830	241·37	678·78	84·16	466·47	1221·80	151·48
500	35·154	0·977	0·0610	1·4814	242·57	678·97	84·92	468 63	1222·15	152·86

To find H and V for wet steam, given Φ, and t or p,

$H_s - H = T(\Phi_s - \Phi)$, or $H = T\Phi - G$.

$V_s - V = V_s(H_s - H)/(H_s - st)$ Cent. $= V_s(H_s - H)/(H_s - s(t - 32))$ Fahr.

TABLE III.—PROPERTIES OF SATURATED STEAM IN TERMS OF TEMPERATURE.

III. (p).—SATURATION PRESSURE p OF STEAM IN POUNDS PER SQ. IN. (LONDON) FOR EACH DEGREE C. FROM 0° TO 259° C.

Temperature. C.	F.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	*32*	0·08922	0·09589	0·10299	0·11056	0·11862	0·12720	0·13632	0·14601	0·15631	0·16724
10	*50*	0·17883	0·19112	0·20415	0·21797	0·23260	0·24810	0·26449	0·28182	0·30014	0·31949
20	*68*	0·33993	0·36157	0·38433	0·40834	0·43366	0·46034	0·48844	0·51804	0·54915	0·58190
30	*86*	0·61618	0·65236	0·69037	0·73030	0·77222	0·81624	0·86234	0·91075	0·96150	1·0147
40	*104*	1·0703	1·1286	1·1896	1·2534	1·3202	1·3900	1·4631	1·5393	1·6187	1·7020
50	*122*	1·7888	1·8793	1·9738	2·0723	2·1750	2·2820	2·3935	2·5096	2·6305	2·7564
60	*140*	2·8873	3·0234	3·1651	3·3123	3·4653	3·6243	3·7896	3·9611	4·1392	4·3240
70	*158*	4·5156	4·7144	4·9205	5·1343	5·3560	5·5857	5·8236	6·0700	6·3253	6·5893
80	*176*	6·8627	7·1451	7·4377	7·7382	8·0525	8·3763	8·7100	9·0534	9·4122	9·7805
90	*194*	10·161	10·553	10·958	11·375	11·806	12·252	12·710	13·182	13·670	14·172
100	*212*	14·689	15·222	15·770	16·335	16·916	17·515	18·127	18·765	19·417	20·088
110	*230*	20·777	21·486	22·214	22·964	23·733	24·523	25·336	26·170	27·027	27·906
120	*248*	28·808	29·733	30·683	31·658	32·658	33·684	34·735	35·813	36·920	38·052
130	*266*	39·213	40·403	41·621	42·869	44·147	45·456	46·690	48·169	49·460	51·011
140	*284*	52·482	53·986	55·525	57·098	58·709	60·355	62·038	63·759	65·516	67·313
150	*302*	69·150	71·025	72·941	74·898	76·897	78·939	81·021	83·150	85·322	87·539
160	*320*	89·800	92·106	94·460	96·861	99·314	101·81	104·36	106·96	109·61	112·31
170	*338*	115·06	117·86	120·72	123·63	126·60	129·62	132·70	135·83	139·03	142·28
180	*356*	145·59	148·95	152·38	155·87	159·43	163·04	166·72	170·46	174·27	178·14
190	*374*	182·08	186·08	190·16	194·29	198·50	202·78	207·12	211·55	216·04	220·60
200	*392*	225·24	229·95	234·73	239·59	244·52	249·53	254·62	259·79	265·05	270·38
210	*410*	275·78	281·26	286·82	292·47	298·20	304·01	309·91	315·90	321·97	328·13
220	*428*	334·38	340·71	347·14	353·66	360·26	366·96	373·76	380·64	387·63	394·70
230	*446*	401·89	409·12	416·46	423·89	431·01	439·06	446·79	454·62	462·56	470 60
240	*464*	478·74	486·95	495·27	503·69	512·21	520·85	529·59	538·43	547·38	556·46
250	*482*	565·63	574·87	584·22	593·69	603·26	612·96	622·74	632·67	642·70	652·84
		0	*1·8*	*3·6*	*5·4*	*7·2*	*9·0*	*10·8*	*12·6*	*14·4*	*16·2*

EQUIVALENT DEGREES AND DECIMALS FAHRENHEIT.

To reduce to kg/sq. cm. (London) multiply by 0·070307.

To reduce to Latitude 45° add 1/2000th part.

To reduce to mms. of mercury (Lat. 45°) multiply by 760/14·689.

Reduction is best effected by the aid of the table of logarithms of the pressure given on the opposite page.

The values of p are calculated from the thermodynamical equation $T\phi - h = T\Phi - H$, to be consistent with those of H and Φ. They agree very closely with experiment from 0° to 200° C. Beyond 200° C. the experimental results become less certain, but the error of the formula is certainly less than 1° C. at 250° C.

TABLE III.—PROPERTIES OF SATURATED STEAM IN TERMS OF TEMPERATURE.

III. (log p).—$\text{Log}_{10}\ p$ for each 1° C. from 0° to 259° C.

Temperature. C.	F.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	*32*	95046	98175	01280	04359	07416	10449	13456	16440	19399	22333
10	*50*	25244	28130	30995	33839	36661	39462	42241	44997	47733	50446
20	*68*	53139	55819	58471	61102	63715	66308	68881	71436	73969	76485
30	*86*	78971	81449	83908	86350	88774	91182	93568	95940	98295	00632
40	*104*	02950	05253	07539	09809	12063	14302	16527	18731	20917	23097
50	*122*	25256	27400	29530	31644	33745	35832	37904	39961	42004	44034
60	*140*	46050	48050	50039	52013	53974	55922	57859	59782	61692	63588
70	*158*	65472	67343	69201	71048	72884	74708	76519	78319	80108	81884
80	*176*	83649	85401	87144	88864	90593	92305	94002	95681	97369	99036
90	*194*	00692	02337	03971	05595	07212	08819	10413	11998	13576	15142
100	*212*	16699	18246	19783	21312	22831	24342	25833	27335	28819	30293
110	*230*	31759	33215	34663	36104	37535	38958	40373	41780	43179	44569
120	*248*	45951	47324	48690	50049	51399	52742	54077	55404	56726	58038
130	*266*	59343	60641	61931	63214	64490	65759	66922	68277	69425	70766
140	*284*	72001	73228	74449	75662	76870	78071	79266	80454	81635	82810
150	*302*	83979	85141	86297	87447	88591	89729	90860	91986	93106	94220
160	*320*	95328	96429	97525	98615	99701	00779	01853	02921	03983	05041
170	*338*	06092	07137	08177	09212	10242	11267	12287	13301	14310	15314
180	*356*	16313	17305	18294	19277	20257	21230	22199	23163	24122	25077
190	*374*	26027	26971	27911	28845	29775	30702	31623	32541	33453	34361
200	*392*	35265	36163	37056	37947	38832	39713	40590	41463	42332	43197
210	*410*	44057	44911	45761	46608	47450	48289	49123	49955	50782	51604
220	*428*	52424	53239	54050	54858	55661	56462	57259	58052	58842	59627
230	*446*	60410	61185	61957	62725	63490	64252	65010	65765	66517	67265
240	*464*	68010	68748	69484	70216	70945	71671	72394	73113	73829	74543
250	*482*	75253	75957	76658	77356	78050	78743	79431	80118	80800	81481
		0	*1·8*	*3·6*	*5·4*	*7·2*	*9·0*	*10·8*	*12·6*	*14·4*	*16·2*

Equivalent Degrees and Decimals Fahrenheit.

$\text{Log}\ p = 21{\cdot}07449 - 2903{\cdot}39/T - 4{\cdot}71734 \log T + 0{\cdot}4057(c - b)p/T.$

To reduce to kg/sq. cm. add log 0·070307 = $\bar{2}{\cdot}84696$. To reduce to mms. of mercury (Lat. 45°) add 1·71382.

The characteristic of the logarithm is omitted, and must be supplied by inspection of the table of p on the opposite page.

The logarithm of the pressure is the quantity directly given by calculation, and most often required for other purposes. It should be used, when possible, in preference to p itself, because this procedure permits a more uniform degree of proportionate accuracy.

TABLE III.—PROPERTIES OF SATURATED STEAM IN TERMS OF TEMPERATURE.

III. (V).—VOLUME OF SATURATED STEAM V_s IN CUBIC FEET PER POUND FOR EACH 1° C. FROM 0° TO 259° C.

Temperature. C.	F.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	*32*	3275·9	3059·3	2858·5	2672·6	2499·9	2339·6	2190·9	2052·6	1924·2	1804·8
10	*50*	1693·8	1590·5	1494·1	1404·3	1320·4	1242·2	1169·2	1101·1	1037·3	977·87
20	*68*	922·19	869·92	821·13	775·45	732·59	692·41	654·84	619·36	586·18	554·98
30	*86*	525·81	498·25	472·33	447·94	424·99	403·33	382·98	363·77	345·64	328·56
40	*104*	312·45	297·24	282·87	269·28	256·45	244·30	232·81	221·96	211·69	201·93
50	*122*	192·72	183·97	175·65	167·84	160 37	153·30	146·58	140·20	134·15	128·38
60	*140*	122·91	117·72	112·76	108·06	103·58	99·307	95·238	91·364	87·673	84·156
70	*158*	80·804	77·606	74·558	71·644	68·861	66·204	63·669	61·244	58·926	56·713
80	*176*	54·596	52·573	50·633	48·791	47·007	45·303	43·677	42·125	40·620	39·187
90	*194*	37·815	36·498	35·235	34·024	32·860	31·743	30·670	29·642	28·651	27·702
100	*212*	26·789	25·911	25·067	24·256	23·476	22·724	22·006	21·306	20·636	19·992
110	*230*	19·370	18·774	18·197	17·641	17·105	16·590	16·092	15·612	15·149	14·702
120	*248*	14·271	13·855	13·454	13·066	12·692	12·330	11·980	11·643	11·316	11·001
130	*266*	10·696	10·401	10·116	9·8404	9·5737	9·3156	9·0870	8·9236	8·6099	8·3627
140	*284*	8·1431	7·9304	7·7245	7·5252	7·3317	7·1443	6·9625	6·7864	6·6158	6·4502
150	*302*	6·2895	6·1339	5·9828	5·8361	5·6939	5·5559	5·4218	5·2916	5·1652	5·0424
160	*320*	4·9232	4·8076	4·6951	4·5860	4·4795	4·3763	4·2758	4·1782	4·0835	3·9911
170	*338*	3·9015	3·8143	3·7295	3·6469	3·5675	3·4884	3·4123	3·3383	3·2661	3·1959
180	*356*	3·1275	3·0611	2·9962	2·9331	2·8714	2·8115	2·7531	2·6962	2·6408	2·5867
190	*374*	2·5339	2·4826	2·4324	2·3838	2·3362	2·2896	2·2444	2·2001	2·1570	2·1148
200	*392*	2·0738	2·0337	1·9948	1·9566	1·9193	1·8830	1·8474	1·8128	1·7788	1·7458
210	*410*	1·7134	1·6819	1·6511	1·6210	1·5916	1·5629	1·5348	1·5073	1·4804	1·4542
220	*428*	1·4285	1·4034	1·3788	1·3548	1·3314	1·3084	1·2860	1·2639	1·2424	1·2214
230	*446*	1·2007	1·1807	1·1611	1·1419	1·1230	1·1046	1·0864	1·0688	1·0555	1·0344
240	*464*	1·0178	1·0017	0·9858	0·9702	0·9549	0·9400	0·9253	0·9110	0·8969	0·8830
250	*482*	0·8695	0·8564	0·8434	0·8306	0·8183	0·8060	0·7940	0·7822	0·7707	0·7594
		0	*1·8*	*3·6*	*5·4*	*7·2*	*9·0*	*10·8*	*12·6*	*14·4*	*16·2*

EQUIVALENT DEGREES AND DECIMALS FAHRENHEIT.

Formula $V_s = 1{\cdot}07061T/p - (c - b)$.
Where $T = t + 273{\cdot}10°$ C., $b = 0{\cdot}0160$, and $c = 0{\cdot}4213(373{\cdot}1/T)^{10/3}$.
p in lbs./sq. in. London. c and b in cubic feet per pound.

To reduce to cubic metres per kilogramme divide by 16·0184 (or divide by 16 and subtract 0·00115 of the result).

To find V for wet steam, given t, and H or Φ, find H_s from Table III., p. 30 (and H from $H = T\Phi - G$, Table III., p. 31, if Φ only is given), and substitute in the formula $V_s - V = V_s(H_s - H)/(H_s - st)$.

TABLE III.—PROPERTIES OF SATURATED STEAM IN TERMS OF TEMPERATURE.

III. (*c*).—Co-aggregation Volume *c* in Cubic Feet per Pound for each 1° C. from 0° to 259° C.

Temperature. C.	F.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	*32*	1·192	1·177	1·163	1·149	1·135	1·122	1·109	1·096	1·083	1·070
10	*50*	1·057	1·045	1·033	1·021	1·009	0·9972	0·9857	0·9744	0·9634	0·9525
20	*68*	0·9417	0·9310	0·9195	0·9101	0·9001	0·8900	0·8803	0·8705	0·8609	0·8514
30	*86*	0·8420	0·8328	0·8237	0·8147	0·8060	0·7973	0·7888	0·7804	0·7720	0·7638
40	*104*	0·7557	0·7477	0·7397	0·7320	0·7243	0·7168	0·7094	0·7020	0·6947	0·6875
50	*122*	0·6804	0·6734	0·6665	0·6597	0·6530	0·6465	0·6400	0·6336	0·6272	0·6209
60	*140*	0·6147	0·6086	0·6025	0·5966	0·5907	0·5850	0·5793	0·5736	0·5680	0·5625
70	*158*	0·5570	0·5516	0·5463	0·5410	0·5358	0·5307	0·5258	0·5208	0·5158	0·5109
80	*176*	0·5061	0·5013	0·4966	0·4920	0·4874	0·4829	0·4785	0·4741	0·4697	0·4654
90	*194*	0·4611	0·4569	0·4527	0·4486	0·4445	0·4404	0·4366	0·4327	0·4288	0·4250
100	*212*	0·4213	0·4174	0·4137	0·4101	0·4064	0·4029	0·3995	0·3960	0·3925	0·3891
110	*230*	0·3857	0·3823	0·3790	0·3758	0·3726	0·3694	0·3663	0·3632	0·3601	0·3570
120	*248*	0·3540	0·3510	0·3480	0·3451	0·3422	0·3393	0·3365	0·3337	0·3310	0·3282
130	*266*	0·3255	0·3228	0·3202	0·3175	0·3149	0·3123	0·3098	0·3073	0·3049	0·3024
140	*284*	0·3000	0·2976	0·2952	0·2929	0·2905	0·2882	0·2860	0·2837	0·2815	0·2793
150	*302*	0·2771	0·2749	0·2727	0·2706	0·2684	0·2663	0·2643	0·2622	0·2602	0·2582
160	*320*	0·2562	0·2542	0·2523	0·2503	0·2484	0·2466	0·2448	0·2430	0·2411	0·2393
170	*338*	0·2375	0·2357	0·2340	0·2322	0·2305	0·2287	0·2270	0·2253	0·2237	0·2220
180	*356*	0·2204	0·2188	0·2172	0·2156	0·2141	0·2126	0·2110	0·2095	0·2080	0·2065
190	*374*	0·2050	0·2035	0·2021	0·2006	0·1992	0·1978	0·1964	0·1950	0·1936	0·1923
200	*392*	0·1909	0·1896	0·1882	0·1869	0·1856	0·1843	0·1830	0·1817	0·1805	0·1792
210	*410*	0·1780	0·1768	0·1756	0·1744	0·1732	0·1720	0·1709	0·1697	0·1686	0·1674
220	*428*	0·1663	0·1652	0·1641	0·1630	0·1619	0·1608	0·1597	0·1587	0·1576	0·1565
230	*446*	0·1555	0·1545	0·1534	0·1524	0·1514	0·1504	0·1495	0·1485	0·1475	0·1466
240	*464*	0·1456	0·1446	0·1437	0·1428	0·1419	0·1410	0·1401	0·1392	0·1383	0·1375
250	*482*	0·1366	0·1357	0·1349	0·1341	0·1332	0·1324	0·1316	0·1308	0·1300	0·1292
		0	*1·8*	*3·6*	*5·4*	*7·2*	*9·0*	*10·8*	*12·6*	*14·4*	*16·2*

Equivalent Degrees and Decimals Fahrenheit.

Formula $c = 0{\cdot}4213(373{\cdot}1/T)^{10/3}$.

Where $T = 273{\cdot}10 + t$, Centigrade.

To reduce to cubic metres per kilo divide by 16·0184. (Divide by 16 and subtract 0·00115 of the result.)

Since *c* is a function of the temperature only, the values given in this table apply to dry steam, whether superheated or supersaturated, as well as to dry saturated steam. The relative values are correct to about 1 in 2000, but the absolute values are uncertain to about 1 per cent.

TABLE III.—PROPERTIES OF SATURATED STEAM IN TERMS OF TEMPERATURE.

III. (H).—TOTAL HEAT H_S OF SATURATED STEAM IN MEAN CALORIES C. FROM 0° TO 259° C. FOR EACH DEGREE.

Temperature. C.	F.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	*32*	594·27	594·75	595·23	595·70	596·18	596·65	597·13	597·60	598·07	598·54
10	*50*	599·01	599·49	599·96	600·43	600·90	601·37	601·84	602·31	602·78	603·25
20	*68*	603·72	604·19	604·66	605·13	605·60	606·06	606·53	607·00	607·47	607·94
30	*86*	608·40	608·87	609·33	609 80	610·26	610·73	611·19	611·65	612·12	612·58
40	*104*	613·04	613·50	613·96	614·42	614·88	615·34	615·80	616·26	616·72	617·18
50	*122*	617·63	618·09	618·54	619·00	619·45	619·90	620·36	620·81	621·26	621·71
60	*140*	622·16	622·61	623·06	623·50	623·95	624·39	624·84	625·28	625·72	626·16
70	*158*	626·60	627·04	627·48	627·91	628·35	628·79	629·22	629·65	630·09	630·52
80	*176*	630·95	631·38	631·80	632·23	632·65	633·08	633·50	633·93	634·35	634·77
90	*194*	635·19	635·61	636·02	636·44	636·85	637·26	637·67	638·08	638·49	638·90
100	*212*	639·30	639·71	640·11	640·51	640·90	641·30	641·69	642·09	642·48	642·87
110	*230*	643·26	643·65	644·04	644·42	644·80	645·18	645·56	645·94	646·32	646·70
120	*248*	647·07	647·44	647·81	648·18	648·55	648·91	649·28	649·64	650·00	650·36
130	*266*	650·72	651·07	651·43	651·78	652·13	652·48	652·82	653·17	653·51	653·85
140	*284*	654·19	654·53	654·86	655·19	655·52	655·85	656·18	656·51	656·83	657·15
150	*302*	657·47	657·79	658·10	658·41	658·72	659·03	659·34	659·65	659·95	660·25
160	*320*	660·55	660·85	661·15	661·44	661·73	662·02	662·31	662·60	662·88	663·16
170	*338*	663·44	663·72	664·00	664·27	664·54	664·81	665·08	665·35	665·62	665·88
180	*356*	666·14	666·40	666·66	666·91	667·17	667·42	667·67	667·92	668·16	668·41
190	*374*	668·65	668·89	669·13	669·37	669·60	669·83	670·06	670·29	670·52	670·74
200	*392*	670·96	671·18	671·40	671·62	671·83	672·04	672·25	672·46	672·67	672·88
210	*410*	673·09	673·29	673·49	673·69	673·89	674·09	674·28	674·48	674·67	674·87
220	*428*	675·06	675·25	675·44	675·62	675·80	675·98	676·16	676·35	676·53	676·70
230	*446*	676·87	677·05	677·22	677·39	677·56	677·73	677·90	678·06	678·22	678·39
240	*464*	678·55	678·71	678·87	679·03	679·19	679·35	679·50	679·66	679·81	679·97
250	*482*	680·12	680·27	680·42	680·57	680·72	680·87	681·02	681·16	681·31	681·45
		0	*1·8*	*3·6*	*5·4*	*7·2*	*9·0*	*10·8*	*12·6*	*14·4*	*16·2*

EQUIVALENT DEGREES AND DECIMALS FAHRENHEIT.

Equation $H_S = S_0 T - (a(n+1)c - ab)p + 464{\cdot}00$.

Where $S_0 = (n+1)R = 13 \times 0{\cdot}11012/3$, and p = saturation pressure in lbs. per sq. in.

$a = 144/1400$. $c = 0{\cdot}4213(T/373{\cdot}1)^{10/3}$. $b = 0{\cdot}0160$.

To reduce to British Thermal Units, multiply by 9/5. (Subtract a tenth and multiply by 2.)

No reduction required for Metric Units C.

To find H for wet steam, given Φ and t. $H = T\Phi - G$.

To find H for wet steam, given V and t. Find V_s from Table III. (V), p. 28, and substitute in the formula, $V_s - V = V_s(H_s - H)/(H_s - st)$.

When Φ and V are given, proceed by trial and interpolation.

TABLE III.—PROPERTIES OF SATURATED STEAM IN TERMS OF TEMPERATURE.

III. (G).—Thermodynamic Potential $G_s = T\Phi_s - H_s$ of Saturated Steam in Mean Calories C. for each 1° from 0° to 259° C.

Temperature. C.	F.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	*32*	0	0·002	0·007	0·016	0·029	0·046	0·066	0·090	0·116	0·146
10	*50*	0·181	0·218	0·259	0·304	0·352	0·405	0·459	0·517	0·579	0·645
20	*68*	0·714	0·79	0·86	0·93	1·01	1·10	1·19	1·28	1·38	1·48
30	*86*	1·58	1·69	1·79	1·90	2·02	2·14	2·26	2·39	2·51	2·64
40	*104*	2·78	2·92	3·06	3·20	3·35	3·50	3·65	3·81	3·97	4·13
50	*122*	4·30	4·47	4·64	4·82	4·99	5·17	5·36	5·55	5·74	5·93
60	*140*	6·13	6·33	6·53	6·74	6·95	7·16	7·37	7·59	7·81	8·03
70	*158*	8·26	8·49	8·72	8·96	9·20	9·44	9·68	9·93	10·17	10·43
80	*176*	10·68	10·94	11·20	11·46	11·73	12·00	12·27	12·54	12·82	13·10
90	*194*	13·38	13·67	13·96	14·25	14·54	14·84	15·13	15·43	15·74	16·05
100	*212*	16·36	16·67	16·99	17·31	17·63	17·95	18·27	18·60	18·93	19·26
110	*230*	19·60	19·94	20·28	20·62	20·97	21·32	21·67	22·02	22·38	22·74
120	*248*	23·10	23·46	23·83	24·20	24·57	24·95	25·33	25·71	26·09	26·47
130	*266*	26·86	27·25	27·64	28·04	28·44	28·84	29·24	29·64	30·04	30·45
140	*284*	30·86	31·27	31·68	32·10	32·52	32·94	33·37	33·80	34·23	34·66
150	*302*	35·10	35·54	35·98	36·42	36·86	37·31	37·76	38·21	38·66	39·12
160	*320*	39·58	40·04	40·50	40·97	41·44	41·91	42·38	42·85	43·33	43·81
170	*338*	44·29	44·77	45·25	45·74	46·23	46·72	47·22	47·72	48·22	48·72
180	*356*	49·22	49·73	50·24	50·75	51·26	51·77	52·29	52·81	53·33	53·85
190	*374*	54·38	54·91	55·44	55·97	56·50	57·04	57·58	58·12	58·66	59·20
200	*392*	59·75	60·30	60·85	61·40	61·96	62·52	63·08	63·64	64·20	64·76
210	*410*	65·33	65·90	66·47	67·04	67·62	68·20	68·78	69·36	69·94	70·53
220	*428*	71·12	71·71	72·30	72·89	73·49	74·09	74·69	75·29	75·89	76·50
230	*446*	77·11	77·72	78·33	78·94	79·56	80·18	80·80	81·42	82·04	82·67
240	*464*	83·30	83·93	84·56	85·19	85·82	86·46	87·10	87·74	88·38	89·03
250	*482*	89·68	90·33	90·98	91·63	92·28	92·94	93·60	94·26	94·92	95·59
		0	*1·8*	*3·6*	*5·4*	*7·2*	*9·0*	*10·8*	*12·6*	*14·4*	*16·2*

Equivalent Degrees and Decimals Fahrenheit.

$$G_s = sT \log_e T/T_0 - st - 0{\cdot}003\ t/T_0$$
$$= 2{\cdot}2949T \log_{10} T/273{\cdot}1 - t + t/300 - 0{\cdot}003\ t/273{\cdot}1$$

where $s = 0{\cdot}99666$, and $T = t + 273{\cdot}10$.

To reduce G to British Thermal Units, multiply by 9/5, or subtract a tenth and multiply by 2.

No reduction required for Metric Units Centigrade.

The value of G is the same for water and saturated steam at the same temperature or pressure, and for a mixture of water and steam in any proportions.

TABLE IV.—TOTAL HEAT H OF SUPERHEATED OR SUPERSATURATED STEAM IN MEAN CALORIES CENTIGRADE.

Temperature. C.	F.	Difference for 10 lbs. *10 S.C.*	Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.) 20 *1·4061*	30 *2·1092*	40 *2·8123*	50 *3·5154*	60 *4·2184*	70 *4·9215*	80 *5·6246*	90 *6·3276*	100 *7·0307*
500	*932*	0·1492	832·61	832·46	832·31	832·16	832·02	831·87	831·72	831·57	831·42
450	*842*	0·1904	808·67	808·48	808·29	808·10	807·91	807·72	807·53	807·34	807·15
400	*752*	0·2464	784·70	784·45	784·20	783·96	783·71	783·47	783·22	782·97	782·73
390	*734*	0·2596	779·90	779·64	779·38	779·12	778·86	778·60	778·34	778·08	777·82
380	*716*	0·2740	775·10	774·82	774·55	774·28	774·00	773·73	773·45	773·18	772·91
370	*698*	0·2892	770·30	770·01	769·72	769·43	769·14	768·85	768·56	768·27	767·98
360	*680*	0·3056	765·49	765·19	764·88	764·57	764·27	763·96	763·66	763·35	763·05
350	*662*	0·3232	760·68	760·36	760·04	759·71	759·39	759·07	758·74	758·42	758·10
340	*644*	0·3420	755·87	755·53	755·19	754·85	754·51	754·16	753·82	753·48	753·14
330	*626*	0·3620	751·06	750·70	750·34	749·98	749·61	749·25	748·89	748·53	748·17
320	*608*	0·3840	746·25	745·86	745·48	745·09	744·71	744·33	743·94	743·56	743·17
310	*590*	0·4072	741·43	741·02	740·61	740·21	739·80	739·39	738·98	738·58	738·17
300	*572*	0·4324	736·61	736·17	735·74	735·31	734·88	734·44	734·01	733·58	733·15
290	*554*	0·4596	731·78	731·32	730·86	730·40	729·94	729·48	729·02	728·56	728·10
280	*536*	0·4888	726·95	726·46	725·97	725·48	724·99	724·50	724·02	723·53	723·04
270	*518*	0·5204	722·11	721·59	721·07	720·55	720·03	719·51	718·99	718·47	717·95
260	*500*	0·5544	717·27	716·72	716·16	715·61	715·06	714·50	713·95	713·39	712·84
250	*482*	0·5920	712·43	711·83	711·24	710·65	710·06	709·47	708·87	708·28	707·69
240	*464*	0·6324	707·57	706·94	706·31	705·68	705·04	704·41	703·78	703·15	702·51
230	*446*	0·6764	702·71	702·04	701·36	700·69	700·01	699·33	698·66	697·98	697·30
220	*428*	0·7244	697·85	697·12	696·40	695·67	694·95	694·23	693·50	692·78	692·05
210	*410*	0·7768	692·97	692·19	691·42	690·64	689·86	689·09	688·31	687·53	686·76
200	*392*	0·8340	688·08	687·25	686·42	685·58	684·75	683·91	683·08	682·25	681·41
190	*374*	0·8968	683·19	682·29	681·39	680·50	679·60	678·70	677·81	676·91	676·01
180	*356*	0·9656	678·28	677·31	676·35	675·38	674·41	673·45	672·48	671·52	670·55
170	*338*	1·0422	673·35	672·31	671·27	670·23	669·19	668·15	667·10	666·06	665·02
160	*320*	1·1256	668·41	667·29	666·16	665·04	663·91	662·79	661·66	660·54	659·41
150	*302*	1·2187	663·46	662·24	661·02	659·80	658·59	657·37	656·15	654·93	653·71
140	*284*	1·3208	658·48	657·16	655·84	654·52	653·20	651·88	650·56	649·24	647·92
130	*266*	1·4345	653·48	652·05	650·61	649·18	647·75	646·31	644·88	643·44	642·01
120	*248*	1·5615	648·46	646·90	645·34	643·77	642·21	640·65	639·09	637·53	635·97
110	*230*	1·7027	643·40	641·70	640·00	638·30	636·59	634·89	633·19	631·49	629·79
100	*212*	1·8608	638·31	636·45	634·59	632·73	630·87	629·01	627·15	625·29	623·43
At saturation temperature.		H.	642·82	647·52	650·95	653·60	655·76	657·60	659·20	660·69	661·82
		C.	108·87	121·28	130·67	138·30	144·79	150·46	155·52	160·09	164·28
		F.	*227·97*	*250·31*	*267·21*	*280·94*	*292·62*	*302·83*	*311·93*	*320·16*	*327·71*

Formula $H = S_0T - SCP + 464{\cdot}00$. $S_0 = 0{\cdot}47719$.

To reduce to B.Th.U. Fahr., subtract a tenth and multiply by 2.

No reduction required for Metric Units (K.M.C.).

Values below the black zigzag line represent supersaturated steam.

TABLE IV.—TOTAL HEAT H OF SUPERHEATED OR SUPERSATURATED STEAM IN MEAN CALORIES CENTIGRADE.

Pressure in pounds per square inch. (Kg. per sq. cm. in italics.)

120 *8·4368*	140 *9·4830*	160 *11·249*	180 *12·655*	200 *14·061*	250 *17·577*	300 *21·092*	350 *24·607*	400 *28·123*	450 *31·638*	500 *35·154*
831·12	830·82	830·52	830·22	829·93	829·18	828·43	827·69	826·94	826·20	825·45
806·77	806·39	806·00	805·62	805·24	804·29	803·34	802·39	801·43	800·48	799·53
782·23	781·74	781·25	780·76	780·26	779·03	777·80	776·57	775·33	774·10	772·87
777·30	776·78	776·26	775·75	775·23	773·93	772·63	771·33	770·03	768·74	767·44
772·36	771·81	771·26	770·71	770·17	768·80	767·43	766·06	764·69	763·32	761·95
767·40	766·83	766·25	765·67	765·09	763·64	762·20	760·75	759·31	757·86	756·41
762·44	761·82	761·21	760·60	759·99	758·46	756·93	755·41	753·88	752·35	750·82
757·45	756·81	756·16	755·51	754·87	753·25	751·63	750·02	748·40	746·79	745·17
752·45	751·77	751·09	750·40	749·72	748·01	746·30	744·59	742·88	741·17	739·46
747·44	746·72	745·99	745·27	744·55	742·74	740·93	739·12	737·31	735·50	733·69
742·41	741·64	740·87	740·10	739·33	737·41	735·49	733·57	731·65	729·73	727·81
737·36	736·54	735·73	734·91	734·10	732·06	730·03	727·99	725·95	723·92	721·88
732·28	731·42	730·55	729·69	728·82	726·66	724·50	722·34	720·17	718·01	715·85
727·18	726·26	725·34	724·43	723·51	721·21	718·91	716·61	714·31	712·02	709·72
722·06	721·08	720·11	719·13	718·15	715·71	713·26	710·82	708·37	705·93	703·49
716·91	715·87	714·83	713·79	712·75	710·14	707·54	704·94	702·34	699·74	697·13
711·73	710·62	709·51	708·40	707·29	704·52	701·75	698·98	696·21	693·43	690·66
706·51	705·32	704·14	702·95	701·77	698·81	695·85	692·89	689·93	686·97	684·01
701·25	699·99	698·72	697·46	696·19	693·03	689·87	686·70	683·54	680·38	677·22
695·95	694·60	693·24	691·89	690·54	687·16	683·77	680·39	677·01	673·63	670·25
690·60	689·16	687·71	686·26	684·81	681·19	677·56	673·94	670·32	666·70	663·08
685·20	683·65	682·10	680·54	678·99	675·10	671·22	667·34	663·45	659·57	655·68
679·74	678·08	676·41	674·74	673·07	668·90	664·73	660·56	656·39	652·22	648·05
674·22	672·43	670·63	668·84	667·04	662·56	658·08	653·59	649·11	644·62	640·14
668·62	666·69	664·76	662·83	660·90	656·07	651·24	646·41	641·58	636·76	631·93
662·94	660·85	658·77	656·69	654·60	649·40	644·19	638·98	633·77	628·56	623·36
657·16	654·91	652·66	650·41	648·16	642·53	636·91	631·28	625·66	620·03	614·40
651·28	648·84	646 41	643·97	641·53	635·44	629·35	623·26	617·17	611·08	604·99
645·28	642·64	640·00	637·36	634·72	628·12	621·52	614 92	608·32	601·72	595·12
639·14	636·27	633·41	630·54	627·67	620·50	613·33	606·16	598·99	591·82	584·65
632·85	629·73	626·61	623·48	620·36	612·56	604·75	596·95	589·15	581·34	573·54
626·38	622·98	619·57	616·17	612·77	604·26	595·75	587·24	578·73	570·22	561·71
619·71	615·99	612·27	608 55	604·83	595·52	586·22	576·92	567·62	558·32	549·01
663·92	665·69	667·22	668·53	669·69	672·08	673·97	675·52	676·84	677·97	678·97
171·75	178·31	184·16	189·48	194·36	205·10	214·32	222·45	229·75	236·42	242·57
341·15	*352·96*	*363·49*	*373·07*	*381·85*	*401·19*	*417·78*	*432·41*	*445·55*	*457·56*	*468·63*

Formula $H = S_0T - SCP + 464{\cdot}00$. $S_0 = 0{\cdot}47719$.

To reduce to B.Th.U. Fahr., subtract a tenth and multiply by 2.

No reduction required for Metric Units (K.M.C.).

Values below the black zigzag line represent supersaturated steam.

TABLE V.—VOLUME *V* OF SUPERHEATED OR SUPERSATURATED STEAM IN CUBIC FEET PER POUND.

Temperature.		Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.)								
C.	F.	20 (*1·4061*)	30 *2·1092*	40 *2·8123*	50 *3·5154*	60 *4·2184*	70 *4·9215*	80 *5·6246*	90 *6·3276*	100 *7·0307*
500	*932*	41·363	27·569	20·671	16·532	13·774	11·803	10·325	9·1754	8·2558
450	*842*	38·678	25·775	19·324	15·453	12·872	11·029	9·6466	8·5714	7·7111
400	*752*	35·988	23·978	17·973	14·370	11·967	10·252	8·9648	7·9640	7·1632
390	*734*	35·450	23·618	17·702	14·152	11·786	10·096	8·8281	7·8421	7·0533
380	*716*	34·912	23·258	17·431	13·935	11·604	9·9396	8·6910	7·7200	6·9430
370	*698*	34·372	22·897	17·160	13·717	11·422	9·7833	8·5537	7·5975	6·8325
360	*680*	33·834	22·537	16·889	13·500	11·240	9·6266	8·4162	7·4748	6·7217
350	*662*	33·295	22·177	16·617	13·282	11·058	9·4698	8·2785	7·3520	6·6107
340	*644*	32·755	21·815	16·345	13·063	10·875	9·3125	8·1403	7·2287	6·4994
330	*626*	32·215	21·454	16·073	12·845	10·692	9·1551	8·0020	7·1052	6·3878
320	*608*	31·675	21·092	15·800	12·626	10·509	8·9973	7·8634	6·9815	6·2760
310	*590*	31·135	20·730	15·528	12·406	10·326	8·8391	7·7243	6·8572	6·1636
300	*572*	30·594	20·368	15·254	12·187	10·141	8·6805	7·5848	6·7327	6·0509
290	*554*	30·052	20·004	14 981	11·966	9·9569	8·5215	7·4449	6·6076	5·9378
280	*536*	29·510	19·641	14·706	11·746	9·7718	8·3620	7·3045	6·4821	5·8241
270	*518*	28·967	19·277	14·431	11·524	9·5863	8·2019	7·1636	6·3560	5·7100
260	*500*	28·425	18·913	14·156	11·303	9·4002	8·0413	7·0221	6·2295	5·5953
250	*482*	27·881	18·547	13·880	11·080	9·2134	7·8800	6·8799	6·1021	5·4798
240	*464*	27·337	18·181	13·603	10·857	9·0260	7·7180	6·7370	5·9741	5·3637
230	*446*	26·791	17·814	13·326	10·632	8·8376	7·5551	6·5933	5·8452	5·2467
220	*428*	26·246	17·447	13·048	10·408	8·6483	7·3913	6·4486	5·7155	5·1289
210	*410*	25·699	17·078	12·768	10·182	8·4582	7·2267	6·3031	5·5848	5·0101
200	*392*	25·150	16·709	12·488	9·9552	8·2668	7·0609	6·1564	5·4529	4·8901
190	*374*	24·601	16·338	12·206	9·7269	8·0743	6·8938	6·0085	5·3199	4·7690
180	*356*	24·050	15·965	11·923	9·4974	7·8805	6·7255	5·8592	5·1855	4·6465
170	*338*	23·497	15·591	11·638	9·2661	7·6850	6·5555	5·7083	5·0495	4·5224
160	*320*	22·944	15·216	11·352	9·0334	7·4878	6·3838	5·5558	4·9118	4·3966
150	*302*	22·388	14·838	11·063	8·7984	7·2886	6·2101	5·4012	4·7721	4·2687
140	*284*	21·829	14·458	10·773	8·5613	7·0871	6·0341	5·2443	4·6301	4·1386
130	*266*	21·268	14·075	10·479	8·3217	6·8832	5·8557	5·0850	4·4856	4·0061
120	*248*	20·705	13·691	10·183	8·0791	6·6762	5·6742	4·9227	4·3382	3·8706
110	*230*	20·138	13·302	9·8840	7·8332	6·4661	5·4896	4·7572	4·1875	3·7318
100	*212*	19·567	12·910	9·5809	7·5837	6·2522	5·3001	4·5878	4·0331	3·5892
Saturation Temperature	C.	108·87	121·28	130·67	138·30	144·79	150·46	155·52	160·09	164·28
	F.	*227·97*	*250·31*	*267·21*	*280·94*	*292·62*	*302·83*	*311·93*	*320·16*	*327·71*

To reduce to cubic metres per kilogram divide by 16·0184 (divide by 16 and subtract 0·00115 of the result).

No reduction required for F.P.F. units.

TABLE V.—VOLUME V OF SUPERHEATED OR SUPERSATURATED STEAM IN CUBIC FEET PER POUND.

Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.)

120	140	160	180	200	250	300	350	400	450	500
8·4368	*9·4830*	*11·249*	*12·655*	*14·061*	*17·577*	*21·092*	*24·607*	*28·123*	*31·638*	*35·154*
6·8763	5·8910	5·1520	4·5772	4·1173	3·2897	2·7379	2·3437	2·0481	1·8182	1·6342
6·4209	5·4993	4·8081	4·2705	3·8404	3·0662	2·5501	2·1815	1·9050	1·6900	1·5179
6·0009	5·1043	4·4609	3·9605	3·5601	2·8395	2·3591	2·0159	1·7586	1·5584	1·3983
5·8701	5·0250	4·3911	3·8982	3·5037	2·7937	2·3205	1·9825	1·7289	1·5317	1·3739
5·7776	4·9452	4·3209	3·8353	3·4469	2·7477	2·2815	1·9486	1·6988	1·5046	1·3492
5·6850	4·8653	4·2506	3·7725	3·3899	2·7014	2·2424	1·9146	1·6687	1·4774	1·3244
5·5921	4·7852	4·1800	3·7093	3·3327	2·6549	2·2030	1·8803	1·6382	1·4499	1·2993
5·4989	4·7048	4·1091	3·6459	3·2753	2·6081	2·1635	1·8458	1·6075	1·4222	1·2740
5·4054	4·6240	4·0379	3·5821	3·2175	2·5611	2·1235	1·8109	1·5765	1·3941	1·2483
5·3117	4·5430	3·9665	3·5182	3·1594	2·5137	2·0833	1·7758	1·5452	1·3659	1·2224
5·2177	4·4618	3·8948	3·4539	3·1011	2·4661	2·0428	1·7404	1·5136	1·3373	1·1962
5·1232	4·3800	3·8226	3·3891	3·0423	2·4179	2 0018	1·7046	1·4816	1·3082	1·1694
5·0284	4·2980	3·7501	3·3240	2·9831	2·3696	1·9605	1·6683	1·4492	1·2788	1·1424
4·9330	4·2153	3·6771	3·2585	2·9235	2·3206	1·9187	1·6317	1·4164	1·2489	1·1149
4·8372	4·1323	3·6036	3·1924	2·8634	2·2712	1·8765	1·5945	1·3830	1·2185	1·0869
4·7409	4 0487	3·5295	3·1258	2·8027	2·2212	1·8337	1·5568	1·3491	1·1876	1·0584
4·6441	3·9646	3·4550	3·0587	2·7416	2·1709	1·7894	1·5186	1·3148	1·1562	1·0294
4·5465	3·8798	3·3797	2·9908	2·6797	2·1196	1·7463	1·4796	1·2796	1·1240	0·9996
4·4481	3·7942	3·3037	2·9222	2·6171	2·0677	1·7015	1·4399	1·2437	1·0911	0·9691
4·3490	3·7078	3·2269	2·8529	2·5536	2·0149	1·6559	1 3994	1·2071	1·0574	0·9377
4·2490	3·6205	3·1492	2·7826	2·4893	1·9614	1·6094	1·3580	1·1695	1·0229	0·9055
4·1481	3·5324	3·0706	2·7114	2·4241	1·9068	1·5620	1·3158	1·1310	0·9874	0·8724
4·0459	3·4430	2·9908	2·6390	2·3576	1·8511	1·5135	1·2723	1·0914	0·9507	0·8381
3·9427	3·3524	2·9097	2 5655	2·2900	1·7941	1·4637	1·2276	1·0505	0·9128	0·8026
3·8380	3·2606	2·8274	2·4906	2·2210	1·7360	1·4126	1·1816	1·0083	0·8736	0·7658
3·7317	3·1670	2·7434	2·4140	2·1504	1·6760	1·3598	1·1339	0·9645	0·8327	0·7273
3·6238	3·0718	2·6578	2·3358	2·0782	1·6145	1·3054	1·0846	0·9190	0·7902	0·6872
3·5138	2·9745	2·5701	2·2555	2·0039	1·5508	1·2489	1·0332	0 8714	0·7456	0·6449
3·4016	2·8751	2·4802	2·1731	1·9273	1·4851	1·1902	0·9796	0·8217	0·6984	0·6005
3·2869	2·7731	2·3878	2·0881	1·8483	1·4167	1·1290	0·9235	0·7694	0·6495	0·5536
3·1791	2·6681	2·2924	2·0001	1·7663	1·3454	1·0649	0·8645	0·7141	0·5972	0·5037
3·0482	2·5599	2·1937	1·9089	1·6810	1·2708	0·9975	0·8022	0·6557	0·5417	0·4506
2·9235	2·4480	2·0913	1·8140	1·5920	1·1926	0·9263	0·7461	0·5934	0·4826	0·3937
171·75	178·31	184·16	189·48	194·36	205·10	214·32	222·45	229·75	236·42	242·57
341·15	*352·96*	*363·49*	*373·07*	*381·85*	*401·19*	*417·78*	*432·41*	*445·55*	*457·56*	*468·63*

Values below the black zigzag line represent supersaturated steam.

Formula $V = 1{\cdot}07061 T/P - 0{\cdot}4213 (T_1/T)^{10/3} + 0{\cdot}0160$,

where $T = 273{\cdot}10 + t$ Cent., and $T_1 = 373{\cdot}10°$.

TABLE VI.—ENTROPY Φ OF SUPERHEATED OR SUPERSATURATED STEAM IN THERMAL UNITS PER DEGREE, CENTIGRADE OR FAHRENHEIT.

Temperature.		Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.)								
C.	F.	20 *1·4061*	30 *2·1092*	40 *2·8123*	50 *3·5154*	60 *4·2184*	70 *4·9215*	80 *5·6246*	90 *6·3276*	100 *7·0307*
500	*932*	07640	03158	99974	97500	95465	93762	92274	90960	89785
450	*842*	04439	99952	96762	94283	92252	90534	89040	87721	86540
400	*752*	01003	96508	93310	90823	88784	87058	85556	84229	83040
390	*734*	00284	95787	92587	90098	88057	86329	84825	83496	82305
380	*716*	99555	95055	91853	89362	87319	85589	84082	82751	81558
370	*698*	98813	94310	91107	88613	86567	84835	83326	81993	80797
360	*680*	98061	93557	90350	87853	85805	84071	82559	81223	80025
350	*662*	97294	92787	89577	87078	85028	83290	81776	80437	79236
340	*644*	96515	92005	88792	86290	84236	82495	80978	79636	78432
330	*626*	95724	91211	87995	85489	83432	81688	80168	78822	77615
320	*608*	94919	90402	87182	84673	82613	80865	79341	77992	76781
310	*590*	94099	89578	86354	83841	81777	80025	78497	77144	75929
300	*572*	93264	88739	85511	82993	80924	79168	77636	76278	75059
290	*554*	92416	87886	84653	82131	80057	78296	76759	75397	74173
280	*536*	91551	87016	83778	81250	79171	77405	75863	74495	73266
270	*518*	90667	86126	82882	80349	78264	76492	74944	73571	72336
260	*500*	89768	85221	81970	79431	77340	75562	74007	72627	71386
250	*482*	88850	84296	81038	78492	76393	74607	73046	71660	70411
240	*464*	87914	83352	80087	77532	75426	73633	72064	70670	69413
230	*446*	86957	82386	79112	76549	74434	72632	71054	69651	68386
220	*428*	85980	81399	78116	75543	73418	71607	70019	68607	67332
210	*410*	84979	80388	77094	74510	72375	70553	68955	67531	66246
200	*392*	83957	79354	76048	73452	71305	69471	67861	66426	65128
190	*374*	82912	78295	74975	72366	70206	68358	66734	65286	63975
180	*356*	81839	77208	73873	71249	69073	67210	65572	64108	62782
170	*338*	80740	76092	72740	70099	67906	66026	64371	62890	61547
160	*320*	79612	74944	71573	68913	66702	64803	63128	61628	60266
150	*302*	78454	73765	70372	67690	65457	63536	61840	60319	58935
140	*284*	77264	72550	69133	66427	64170	62225	60504	58958	57550
130	*266*	76038	71297	67852	65118	62832	60859	59111	57537	56101
120	*248*	74776	70002	66525	63759	61442	59437	57656	56050	54583
110	*230*	73473	68663	65149	62347	59993	57952	56134	54492	52988
100	*212*	72127	67275	63720	60876	58479	56396	54538	52852	51307
Saturation Temperature	C.	108·87	121·28	130·67	138·30	144·79	150·46	155·52	160·09	164·28
	F.	*227·97*	*250·31*	*267·21*	*280·94*	*292 62*	*302·83*	*311·93*	*320·16*	*327·71*

The characteristic (or figure before the decimal point) and the decimal point are omitted. The characteristic is always unity, except for the first four values under 20 lbs., and the first only under 30 lbs., for which the characteristic is 2.

The entropy is the same in all systems of units.

TABLE VI.—ENTROPY Φ OF SUPERHEATED OR SUPERSATURATED STEAM IN THERMAL UNITS PER DEGREE, CENTIGRADE OR FAHRENHEIT.

Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.)										
120 *8·4368*	140 *9·4830*	160 *11·249*	180 *12·655*	200 *14·061*	250 *17·577*	300 *21·092*	350 *24·607*	400 *28·123*	450 *31·638*	500 *35·154*
87744	86014	84511	83180	81987	79448	77357	75578	74024	72647	71403
84488	82747	81233	79891	78687	76120	74002	72195	70614	69207	67938
80972	79215	77685	76327	75107	72500	70342	68495	66874	65427	64118
80233	78472	76938	75576	74352	71735	69567	67710	66079	64622	63303
79482	77716	76177	74811	73583	70955	68776	66908	65266	63798	62468
78716	76946	75402	74031	72798	70158	67957	66087	64433	62953	61611
77939	76164	74615	73239	72001	69349	67145	65253	63586	62094	60739
77144	75363	73810	72428	71184	68518	66300	64394	62713	61207	59838
76334	74547	72987	71599	70349	67667	65434	63512	61816	60294	58910
75510	73717	72150	70755	69499	66800	64551	62612	60900	59361	57961
74670	72868	71295	69893	68629	65913	63645	61689	59958	58402	56983
73809	72000	70419	69009	67737	65001	62713	60737	58986	57409	55971
72930	71113	69523	68104	66823	64065	61755	59757	57984	56386	54925
72035	70208	68608	67180	65890	63108	60775	58733	56957	55335	53851
71117	69280	67669	66231	64930	62121	59762	57714	55891	54242	52732
70176	68327	66705	65255	63943	61106	58718	56641	54790	53113	51574
69213	67351	65717	64254	62929	60060	57640	55531	53648	51939	50368
68224	66348	64699	63222	61883	58978	56523	54378	52460	50715	49109
67210	65319	63654	62161	60807	57863	55369	53186	51228	49444	47799
66166	64257	62575	61065	59693	56706	54168	51941	49949	48113	46424
65093	63165	61464	59934	58543	55508	52922	50647	48598	46723	44986
63985	62036	60313	58763	57350	54261	51622	49294	47191	45262	43472
62844	60870	59123	57549	56112	52964	50264	47876	45713	43725	41874
61664	59663	57890	56288	54825	51609	48843	46387	44158	42103	40185
60440	58410	56606	54975	53481	50190	47348	44817	42512	40379	38388
59171	57107	55270	53604	52076	48700	45774	43157	40767	38550	36473
57852	55750	53874	52170	50604	47133	44110	41399	38914	36601	34428
56478	54332	52413	50666	49057	45478	42348	39527	36934	34514	32232
55044	52849	50881	49085	47428	43726	40474	37532	34816	32274	29872
53539	51289	49265	47413	45700	41859	38467	35386	32531	29850	27307
51957	49643	47555	45639	43863	39861	36310	33071	30057	27214	24513
50290	47903	45742	43754	41903	37720	33988	30563	27367	24345	21460
48525	46053	43809	41736	39803	35410	31467	27835	24429	21194	18102
171·75 *341·15*	178·31 *352·96*	184·16 *363·49*	189·48 *373·07*	194·36 *381·85*	205·10 *401·19*	214·32 *417·78*	222·45 *432·41*	229·75 *445·55*	236·42 *457·56*	242·57 *468·63*

Values below the black zigzag line represent supersaturated steam.

$\Phi = 1·09876 \log (T/T_1) - 0·25356 \log (P/P_1) - ancP/T + 1·76300$,

where $T_1 = 373·10°$, $P_1 = 14·6890$, and the logs are to the base 10.

TABLE VII.—THERMODYNAMIC POTENTIAL, $G = T\Phi - H$, OF SUPERHEATED OR SUPERSATURATED STEAM, IN MEAN CALORIES CENTIGRADE.

Temperature. C.	F.	20 *1·4061*	30 *2·1092*	40 *2·8123*	50 *3·5154*	60 *4·2184*	70 *4·9215*	80 *5·6246*	90 *6·3276*	100 *7·0307*
		Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.)								
500	*932*	772·65	738·16	713·69	694·71	679·20	666·11	654·75	644·75	635·81
450	*842*	669·63	637·37	614·51	596·77	582·27	570·03	559·42	550·07	541·72
400	*752*	568·26	538·24	516·97	500·47	486·99	475·62	465·75	457·07	449·31
390	*734*	548·18	518·63	497·67	481·42	468·14	456·95	447·24	438·71	431·04
380	*716*	528·19	499·08	478·44	462·44	449·37	438·34	428·78	420·36	412·85
370	*698*	508·28	479·62	459·30	443·55	430·68	419·83	410·42	402·13	394·73
360	*680*	488·44	460·22	440·22	424·72	412·07	401·38	392·12	383·97	376·69
350	*662*	468·65	440·91	421·23	405·97	393·52	383·01	373·90	365·88	358·72
340	*644*	448·96	421·66	402·30	387·30	375·05	364·71	355·76	347·88	340·83
330	*626*	429·35	402·49	383·46	368·71	356·67	346·51	337·70	329·95	323·03
320	*608*	409·82	383·42	364·70	350·20	338·37	328·38	319·73	312·10	305·31
310	*590*	390·37	364·41	346·03	331·78	320·15	310·33	301·83	294·35	287·67
300	*572*	370·99	345·50	327·43	313·44	302·00	292·37	284·03	276·67	270·12
290	*554*	351·72	326·67	308·92	295·18	283·96	274·50	266·31	259·10	252·66
280	*536*	332·52	307·93	290·50	277·01	266·00	256·72	248·67	241·60	235·29
270	*518*	313·41	289·26	272·16	258·92	248·13	239·01	231·13	224·19	218·01
260	*500*	294·38	270·70	253·92	240·94	230·34	221·42	213·68	206·89	200·82
250	*482*	275·45	252·22	235·78	222·94	212·65	203·91	196·33	189·66	183·73
240	*464*	256·62	233·84	217·72	205·25	195·07	186·50	179·08	172·56	166·74
230	*446*	237·88	215·56	199·76	187·54	177·58	169·18	161·93	155·54	149·86
220	*428*	219·23	197·36	181·90	169·93	160·18	151·97	144·87	138·62	133·07
210	*410*	200·66	179·26	164·12	152·42	142·88	134·86	127·91	121·81	116·38
200	*392*	182·22	161·28	146·47	135·02	125·70	117·85	111·07	105·11	99·81
190	*374*	163·88	143·39	128·92	117·73	108·63	100·96	94·34	88·53	83·35
180	*356*	145·65	125·63	111·48	100·55	91·66	84·19	77·73	72·06	67·02
170	*338*	127·51	107·95	94·14	83·48	74·79	67·53	61·23	55·71	50·80
160	*320*	109·49	90·41	76·93	66·54	58·08	50·98	44·85	39·48	34·71
150	*302*	91·59	72·97	59·83	49·70	41·47	34·56	28·60	23·38	18·75
140	*284*	73·80	55·65	42·86	32·99	24·98	18·27	+12·48	+7·41	+2·92
130	*266*	56·14	38·46	26·00	+16·41	+8·63	+2·11	−3·50	−8·41	−12·77
120	*248*	37·59	21·38	+9·28	−0·03	−7·58	−13·91	19·34	24·09	28·30
110	*230*	21·18	+4·46	−7·30	16·34	23·65	29·77	35·03	39·62	43·68
100	*212*	+3·89	−12·35	23·76	32·51	39·58	45·49	50·58	55·00	58·90
Saturation Temperature	C.	108·87	121·28	130·67	138·30	144·79	150·46	155·52	160·09	164·28
	F.	*227·97*	*250·31*	*267·21*	*280·94*	*292·62*	*302·83*	*311·93*	*320·16*	*327·71*

The sign of G changes from positive to negative a little below the saturation line, as indicated by the signs + and −.

$$G = S_0 T \log_e (T/T_1) - RT \log_e (P/P_1) + a(c-b)P + (\Phi_1 - S_0)T - B$$

where $T_1 = 373{\cdot}10°$, $P_1 = 14{\cdot}6890$ lbs., $\Phi_1 = 1{\cdot}76300$, $B = 464{\cdot}00$, $S_0 = 0{\cdot}47719$.

TABLE VII.—THERMODYNAMIC POTENTIAL, $G = T\Phi - H$, OF SUPERHEATED OR SUPERSATURATED STEAM, IN MEAN CALORIES CENTIGRADE.

Pressure in pounds per sq. in. (Kg. per sq. cm. in italics.)

120 *8·4368*	140 *9·4830*	160 *11·249*	180 *12·655*	200 *14·061*	250 *17·577*	300 *21·092*	350 *24·607*	400 *28·123*	450 *31·638*	500 *35·154*
620·32	607·24	595·93	585·93	577·02	558·12	542·70	529·70	518·44	508·51	499·66
527·27	515·06	504·48	495·16	486·84	469·22	454·86	442·76	432·28	423·05	414·81
435·88	424·55	414·74	406·09	398·37	382·05	368·75	357·55	347·88	339·36	331·78
417·82	406·66	397·00	388·50	380·90	364·84	351·75	340·74	331·24	322·85	315·41
399·83	388·85	379·35	370·97	363·50	347·70	334·84	324·01	314·66	306·44	299·11
381·92	371·12	361·76	353·53	346·18	330·65	318·00	307·36	298·18	290·10	282·91
364·08	353·46	344·27	336·17	328·95	313·67	301·24	290·79	281·78	273·84	266·79
346·33	335·88	326·84	318·87	311·78	296·77	284·57	274·31	265·46	257·68	250·77
328·66	318·38	309·50	301·67	294·70	279·96	267·98	257·91	249·23	241·60	234·83
311·06	300·96	292·25	284·56	277·70	263·23	251·48	241·60	233·09	225·60	218·98
293·55	283·63	275·07	267·53	260·80	246·60	235·07	225·39	217·05	209·73	203·23
276·13	266·39	257·98	250·57	243·98	230·05	218·75	209·27	201·10	193·94	187·58
258·79	249·23	240·98	233·72	227·24	213·60	202·53	193·24	185·26	178·24	172·04
241·54	232·18	224·08	216·96	210·62	197·25	186·40	177·32	169·51	162·67	156·60
224·38	215·20	207·26	200·29	194·07	180·99	170·38	161·50	153·87	147·18	141·27
207·31	198·32	190·54	183·71	177·63	164·82	154·45	145·78	138·34	131·81	126·05
190·34	181·54	173·93	167·24	160·29	148·77	138·63	130·17	122·91	116·56	110·96
173·47	164·84	157·40	150·86	145·04	132·80	122·92	114·67	107·60	101·42	95·98
156·71	148·27	140·98	134·60	128·91	116·96	107·33	99·30	92·42	86·42	81·14
140·04	131·79	124·68	118·43	112·89	101·24	91·86	84·04	77·36	71·55	66·42
123·47	115·41	108·47	102·38	96·97	85·63	76·50	68·91	62·43	56·80	51·85
107·01	99·14	92·38	86·44	81·16	70·13	61·26	53·74	47·64	42·19	37·42
90·67	83·00	76·40	70·63	65·50	54·77	46·17	39·04	32·99	27·75	23·16
74·44	66·97	60·55	54·93	49·95	39·54	31·21	24·32	18·50	+13·45	+9·05
58·35	51·07	44·83	39·38	34·55	24·46	16·41	+9·77	+4·17	−0·67	−4·87
42·36	35·29	29·24	23·94	19·26	+9·51	+1·74	−4·64	−10·01	−14·62	−18·62
26·51	+19·65	+13·77	+8·66	+4·12	−5·28	−12·75	−18·86	−23·99	28·48	32·17
+10·78	+4·14	−1·54	−6·50	−10·87	−19·93	−27·07	32·91	37·78	41·94	45·50
−4·80	−11·22	−16·71	−21·48	−25·69	34·39	41·22	46·77	51·38	55·29	58·61
20·22	−26·43	31·72	36·31	40·35	48·67	55·17	60·42	64·74	68·39	71·48
35·49	41·48	46·57	50·96	54·84	62·76	68·91	73·84	77·87	81·24	84·07
50·61	56·36	61·22	65·43	69·11	76·63	82·42	87·02	90·75	93·82	96·36
65·56	71·06	75·71	79·72	83·21	90·30	95·70	99·95	103·36	106·11	108·36
171·75	178·31	184·16	189·48	194·36	205·10	214·32	222·45	229·75	236·42	242·57
341·15	*352·96*	*363·49*	*373·07*	*381·85*	*401·19*	*417·78*	*432·41*	*445·55*	*457·56*	*468·63*

To reduce to B.Th.U. Fahr., subtract a tenth and multiply by 2.
No reduction required for Metric Units (K.M.C.).
Values below the black zigzag line represent supersaturated steam.

NOTE

The diagram has been specially devised and adapted for practical calculation and measurement by means of lines, such as the characteristic curve of a turbine or nozzle, which are intended to be drawn on the diagram itself. Examples of such methods are given in the Author's book on the Properties of Steam. The single copy of the diagram supplied with these Tables would be inadequate for long-continued use, and its accuracy is somewhat impaired by folding. Arrangements have accordingly been made by the Publishers for supplying additional copies of the diagram at a moderate price.

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